10 TOP TECH TRENDS OF 2011

Popular Mechanics

SAVE $1000
How High-Tech Wood Heating Pays Off
PAGE 56

SCIENCE TECHNOLOGY AUTOMOTIVE HOME OUTDOORS

JANUARY 2011 • POPULARMECHANICS.COM

Beyond The Flying Car

(Go Ahead, Laugh)
But NASA, DARPA & The FAA Are Serious

NASA's one-person tilt-rotor helicopter, the Puffin, could be airborne this month.

We Test-Drive Two 100-MPG Cars

Next-Gen 3D: Inside Tron

Our Kind of Ballet: Dancing Tanks

diy

Brew Your Own Beer

Build an HDTV Antenna

Change a Light Bulb *(And the Fixture Too)*

Project Plans: Rolling Cabinet

IMMERSE YOURSELF IN A WHOLE NEW DIMENSION

Blu-ray 3D

Bring the Theatrical 3D Experience Home

With Combo Packs featuring Blu-ray™, DVD, Digital Copy, and NOW Blu-ray 3D™!

Plus look for many more Disney Blu-ray 3D titles coming in 2011!

Visit us at **DisneyBluray3D.com**

Popular Mechanics

2011
Jan.
PM FEATURES ///
VOL. 188 NO. 1

With his aerial motorcycle, the Switchblade, Sam Bousfield, of Nevada City, Calif.—founder and president of Samson Motorworks—is moving beyond the traditional flying-car model.

ON THE COVER

The Switchblade, by Samson Motorworks, and the commercial version of NASA's Puffin, illustrated by Jeremy Cook, are two of several new personal-air-vehicle designs aiming to transform the way we travel.

PHOTOGRAPH BY **NATHANIEL WELCH**

Popular Mechanics
PM DEPARTMENTS
NEW TOOLS / CARS / HOME / HOW-TO

× COLUMNS

At Beacon Power in upstate New York, flywheels reach utility scale (page 40).

× TECH WATCH

× UPGRADE

× NEW CARS

× HOME

× AUTO

× TECH

PHOTOGRAPH BY SPENCER LOWELL, ILLUSTRATION BY NATHAN DANIELS

Hear.

Be heard.

NEW The Bose® *Bluetooth*® headset.

Finally, better sound quality for both ends of your calls.

Introducing the first *Bluetooth* headset from Bose that does what others cannot. The Bose *Bluetooth* headset lets you hear and be heard, even as noise levels change. It is engineered with proprietary technologies, so voices sound the way they should and you can hear what is being said better than ever before. In addition, an exclusive noise-rejecting microphone combined with digital signal processing allows you to be heard even when calling from a noisy environment. By combining advanced design and materials, this headset stays securely and comfortably in place. No other *Bluetooth* headset offers all this. Experience it for yourself, and discover how much better you can hear, and be heard.

To learn more,
call 1-800-486-7145, ext. 3061 or visit Bose.com/mobile

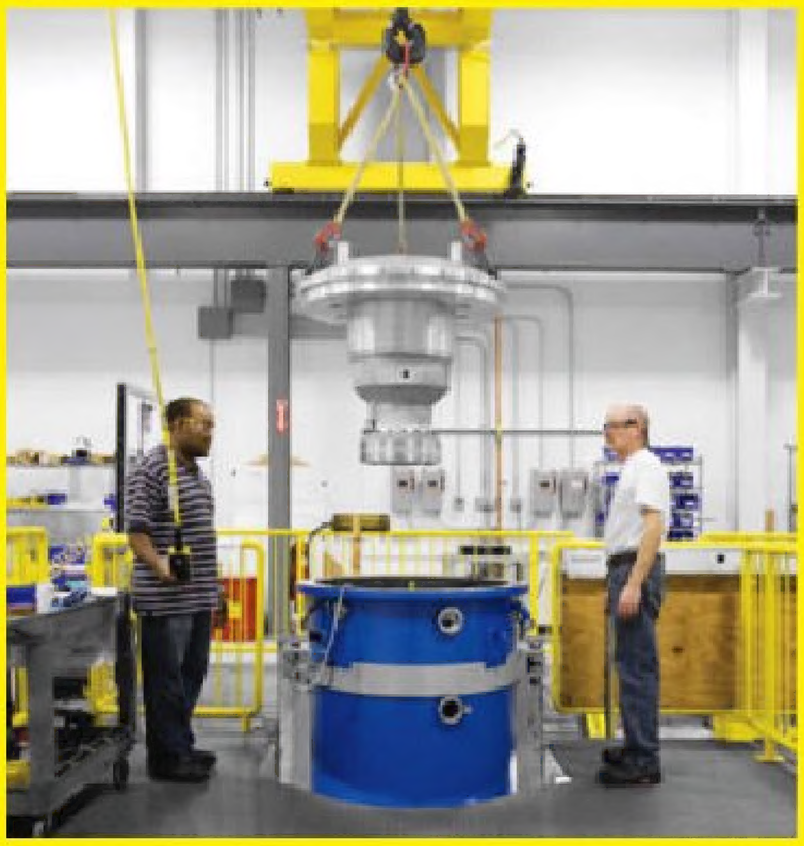
BOSE®
Better sound through research®

PopularMechanics.com

AUTOMOTIVE + SCIENCE + TECHNOLOGY + HOME + HOW-TO CENTRAL + VIDEO

JANUARY

TECH TO KNOW This issue of Popular Mechanics predicts some of the tech concepts that will spur innovation in 2011 (page 40). Review past years' lists to see how we did—with anthropomimetic machines, high-k transistors and more. ***popularmechanics.com/technology***



THE YEAR IN GADGETS Our technology editors report live from the Consumer Electronics Show in Las Vegas on the new year's gadgets, important trends and next-generation technology, as seen at the biggest venue in the tech world. ***popularmechanics.com/CES2011***

ELECTRONICS BUYER'S GUIDE It's hard to pinpoint when to buy a new laptop, smartphone, tablet or television—the technology driving these devices moves too fast. Our tech editors slow it all down, helping you future-proof purchases by choosing the right features, paying a smart price—and avoiding dead-end formats. ***popularmechanics.com/technology/gadgets***

For extra photos and video from our editors, follow Popular Mechanics on Twitter at @PopMech and on Facebook at facebook.com/popularmechanics.

WHEN YOU PEAK, YOU WIN.™

Whatever you drive, PEAK® can take it on. PEAK® Long Life® Antifreeze is formulated with an advanced organic technology to protect the engine of any car or light truck for 5 years or 150,000 miles*.

*A complete cooling system flush and fill, and compliance with coolant maintenance specified in vehicle's owner's manual (including top-offs) are required.

Available at these and other fine retailers:

AutoZone · O'Reilly Auto Parts · Pep Boys Auto · Advance Auto Parts

Need Motor Oil or Windshield Wash?
Look for these other
PEAK® Performance Products.

Official Motor Oil of the IndyCar Series and the Indianapolis 500®

www.peakauto.com

PopularMechanics

JAMES B. MEIGS
Editor-In-Chief

Executive Editor David Dunbar
Design Director Michael Lawton

EDITORIAL
Editor, Automotive Larry Webster
Senior Editor, Automotive Mike Allen
Senior Editor, Home Roy Berendsohn
Senior Editor, Science Jennifer Bogo
Senior Editor, Technology Glenn Derene
Senior Editor Joe Pappalardo
Associate Editors G.E. Anderson, Erin McCarthy, Seth Porges, Harry Sawyers
Research Director David Cohen
Assistant to the Editor-In-Chief Allie Haake
West Coast Editor Ben Stewart
Special Projects Editor Joe Bargmann

Contributing Editors:
Davin Coburn, Andrew English, John Galvin, Jim Gorman, Chris Grundy, Carl Hoffman, John Pearley Huffman, Alex Hutchinson, Joel Johnson, Thomas D. Jones, Dan Koeppel, Jay Leno, Fred Mackerodt, The MythBusters (Jamie Hyneman, Adam Savage), Joe Oldham, Glenn Harlan Reynolds, Rex Roy, Noah Shachtman, Erik Sofge, Kalee Thompson, Joseph Truini, James Vlahos, Logan Ward, Basem Wasef, Barry Winfield, Jeff Wise

Deputy Editor Jerry Beilinson
Managing Editor Michael S. Cain

ART
Senior Art Director Peter Herbert
Associate Art Directors Mike Ley, R. Scott Wells

PHOTOGRAPHY
Director of Photography Allyson Torrisi
Associate Photo Editor Michele Ervin

PRODUCTION
Assistant Managing Editor Jamie Beckman
Copy Editor Robin Tribble
Digital Assets Editor Ed Manning

IMAGING
Digital Imaging Specialist Anthony Verducci

POPULARMECHANICS.COM
Online Director Angela Diegel
Online Editor Tyghe Trimble
Online Producer Carl Davis

POPULAR MECHANICS INTERACTIVE
Technical Lead Jeremy Berman
Developers Alexander Karpodinis, Johnny Tablada
Producer Spencer Lloyd

SPECIAL PROJECTS
Researcher Alyson Sheppard
Digital Edition Art Director John Walker

INTERNS
Shannon Hassett, Kathryn Kennedy

Contributing Photographers & Illustrators:
Burcu Avsar, Levi Brown, Leandro Castelao, Zach DeSart, Dogo, Christopher Griffith, Chad Hunt, Scott Jones, Dennis Kleiman, Andres Rivera, Axel de Roy, Dan Saelinger, Gabriel Silveira, Art Streiber, Supertotto, Dan Winters

SUBSCRIPTIONS
subscribe.popularmechanics.com

BILL CONGDON
Publisher

Associate Publisher Jane Wladar | *General Manager* Bruce A. Mitnick
Executive Marketing Director Mike Kresch

Online Advertising Director Matthias Wolf
Marketing Director Barbara Serino
Group Production Director Karen Otto
Group Production Manager Jackie Beck
Associate Production Manager Karen Nazario

Creative Director Glen Fuenmayor
Marketing Manager Chad Meany
Online Associate Marketing Manager Carolyn Yanoff
Advertising Coordinator John O'Keefe
Vice President, Group Consumer Marketing Director Rick Day

ADVERTISING SALES OFFICES

NEW YORK
East Coast Sales Manager Ray Rienecker *212/649-2876*
Account Manager Matthew Schwagerl *212/649-2902*
Account Manager Cameron Albergo *212/649-2901*
Sales Assistant Alexandra Ward *212/649-2898*

CHICAGO
Manager Spencer J. Huffman *312/984-5191*
Account Manager Matt Avery *312/251-5355*
Sales Assistant Yvonne Villareal *312/984-5196*

SPECIAL SECTION SALES
Beth Boyle *914/461-3269*

DIRECT RESPONSE ADVERTISING
Angela Hronopoulos *212/649-2930*

LOS ANGELES
Account Manager Brittany Marquis *310/664-2921*
Sales Assistant Cari Nelson *310/664-2922*

DETROIT
Manager Robert Reynolds *248/614-6120*
Sales Assistant Toni Starrs *248/614-6011*
Hearst Magazines Sales, Inc.

DALLAS
Account Manager Patty Rudolph *214/824-9008*
Weikel Media

SAN FRANCISCO
Northwest Manager Andrea Wiener *415/828-0908*
Athena Media Partners

CLASSIFIED ADVERTISING REPRESENTATIVE
Kathleen Gleason *888/473-0788; fax: 708/352-4094*
Klassmark, 52 W. Burlington Ave., La Grange, IL 60525

PUBLISHED BY THE HEARST CORPORATION

Frank A. Bennack, Jr.
Vice Chairman & Chief Executive Officer

George R. Hearst, Jr.
Chairman

HEARST MAGAZINES DIVISION

Cathleen P. Black, *Chairman*
David Carey, *President*
Michael Clinton, *President, Marketing & Publishing Director*
John P. Loughlin, *Executive Vice President & General Manager*
Ellen Levine, *Editorial Director*
Gilbert C. Maurer, *Publishing Consultant*
Mark F. Miller, *Publishing Consultant*

how to reach us

E-Mail *popularmechanics@hearst.com*. **Mail** Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. **Fax** 646-280-1081. Please include your name, address and a daytime phone number. Letters may be edited. **Subscription Questions** For customer service, change of address and subscription orders, log on to *service.popularmechanics.com*, or write to **Customer Service Department, Popular Mechanics, P.O. Box 6000, Harlan, IA 51593.** **Back Issues** Write to **Hearst Single Copy Sales, P.O. Box 6000, Harlan, IA 51593.** **Reprints** E-mail *PMreprints@hearst.com*.

EDITORIAL BOARD OF ADVISERS

POPULAR MECHANICS is grateful to these scientists, innovators and leaders, who help ensure we cover the most important stories in the most authoritative way.

BUZZ ALDRIN
Apollo 11 astronaut; colonel, U.S. Air Force (Ret.)
SHAWN CARLSON
Executive director of the Society for Amateur Scientists; MacArthur Fellow
DAVID E. COLE
Chairman, Center for Automotive Research
SAUL GRIFFITH
Chief scientist, Other Lab; MacArthur Fellow
THOMAS D. JONES
Space shuttle astronaut; author of *Sky Walking*
GAVIN A. SCHMIDT
Climate modeler, NASA Goddard Institute for Space Studies
AMY B. SMITH
MIT instructor; leader in appropriate technology movement
DANIEL H. WILSON
Roboticist; co-author of *Mad Scientist Hall of Fame*
WM. A. WULF
President, National Academy of Engineering

WHAT THEY'RE DOING

DR. KEN KAMLER

Microsurgeon Ken Kamler was slated to speak at November's Risky Business conference in London. First organized in 2006, the annual conference explores the role of human error in the medical field by examining such diverse areas as industrial disasters and mountaineering accidents. Kamler was tapped to speak about survival and his experience saving climbers in 1996 on the deadliest day in Mount Everest history.

Bravo, Breakthrough!

Your November issue's 20 Bold Ideas cover story ("Breakthrough Awards 2010") was brilliant. The scope of research today is breathtaking, and you cover it all. Bravo! J. Craig Venter was first brought to my attention in 1990 by a science professor who was very excited about the prospects of the Human Genome Project. It rekindled my interest in science. I love your magazine. Keep up the great work.

KATHRINE WAGSTAFF
SQUIRES, MO

Something Fishy

In "Treacherous Waters," you advocate for greater government regulation of the fishing industry. I disagree. I've dealt with government regulations quite a bit—as a farmer, an ultra-light-aircraft owner, a U.S. Army serviceman and even as a schoolteacher—and I've often found them to be more of a hindrance than a help. In fact, many of the regulations I've had to follow felt like they were written by someone who knew little about the subject and led to major inconvenience and minimal benefit. The last thing we need is more regulation.

ROBERT J. OTTO
CRYSTAL, ND

Full Steam Ahead

Jay Leno's piece about the steam-powered car ("Magnificent Obsession: The Doble Steam Car") was fascinating. As a longtime believer in the feasibility of steam-powered road vehicles, I was pleased to see the story. As usual, Leno did a bang-up job covering the automotive subject (no pun intended).

LEON J. WHITE
COLUMBIANA, OH

When Left Is Right

I like your reviews on power tools and especially enjoyed the one on circular saws ("We Came, We Sawed"). However, you missed one important aspect: whether a particular saw is available in a blade-left configuration. For many professionals who are switching from typically right-handed worm-drive skill saws, the "blade left" configuration is critically important. I hope your future tests will note whether a particular tool offers this option.

STEVE HALL
NEW BERN, NC

Benedikt Heim, of Kempten, Germany, takes POPULAR MECHANICS to new heights atop Reuterwanne, a 5059-foot mountain in the Bavarian Alps.

.ON

ISSUE
11/10

Readers share thoughts about the 2010 Breakthrough Awards, commercial-fishing safety, a 1925 steam-powered car and more.

Get Your Photo in PM!

Caught in the act of enjoying your favorite magazine? ***Send us a snapshot of yourself or someone you know reading the latest issue of POPULAR MECHANICS and your photo could appear on an upcoming Letters page.*** Send a hi-res (300 dpi) digital image—or, what the heck, send a few—with your name, e-mail address and a short note about why you love PM to *popularmechanics@hearst.com*. We'll contact you if we're considering your pic for publication.

Calling All Hometown Heroes

Have you made a major impact on your local community with an innovative DIY project? Has a friend or family member helped to improve the lives of others with an inspiring technological or environmentally savvy endeavor? If so, we want to know about it! In our August 2010 issue, we ran a story about four generous (and ingenious) people who spearheaded big-impact neighborhood projects, from a skateboard park for at-risk kids in northeast Philadelphia to the Homes For Our Troops program, which provides severely disabled veterans with new houses.

For details and entry information about this year's Hometown Heroes Awards, please visit popularmechanics.com/hometownhero.

what do you think?

Write to Us Send e-mail to ***popularmechanics@hearst.com***. Please include your full name, home address and daytime phone number. All letters are subject to editing for length, style and format.

Subscribe PM delivers! Go to ***subscribe.popularmechanics.com***.

When machines start driving machines we'll consider a change.

Computers can measure performance. But computers can't feel. They don't have a pulse. Which is why Infiniti has a Master Driver, recognized by the Ministry of Japan for his extraordinary skill. His sole job is to provide engineers with human feedback. Emotional feedback. One drive in a G Sedan, Coupe, Convertible or the new G25 Sedan, and you'll instantly feel the exhilarating difference he makes. This is inspired performance. This is the way of Infiniti.

Learn more about the new G25 and the remarkable G Line at InfinitiUSA.com.

Vehicle shown is G37 with Sport Package. Always wear your seat belt, and please don't drink and drive. ©2011 INFINITI.

Shodo art by Masako Inkyo

INFINITI.

Inspired Performance

Tech Watch

Mysteries of Our Neighborhood Star

NASA has selected the experiments that will be carried by its Solar Probe Plus mission, which is currently scheduled to launch by 2018. The probe will try to unravel two mysteries about the sun: Why is the corona so much hotter than the surface? And how does the sun generate solar winds that can threaten—or could, someday, power—Earth's electrical grids? To answer these questions, the spacecraft will fly close to 4 million miles from the sun's surface, the carbon-composite heat shield withstanding intense radiation and temperatures exceeding 2500 F. — *ALEX HUTCHINSON*

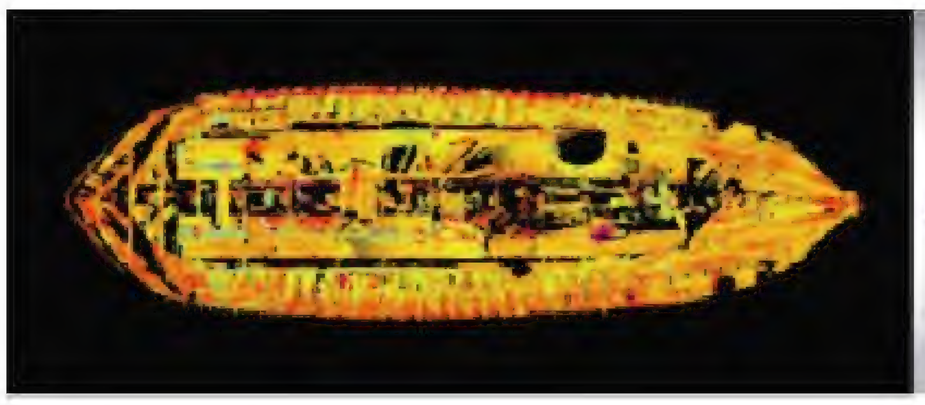
• QUICK HITS

Harnessing Humidity

→ Brazilian scientists believe that the next great renewable energy resource could reside in the tropical air all around them. Their experiments show that airborne water acquires a charge when it interacts with tiny, floating silica and aluminum phosphate dust particles, rather than remaining electrically neutral as previously thought. The researchers suggest placing "hygroelectric" panels in tropical regions to produce trickles of electricity. Even if this renewable-energy scheme doesn't work out, the panels could be placed on buildings to drain power from the air before it's discharged as lightning.

Critter Toilets Record Earth's Climate Changes

→ British geographers are scaling remote rock formations in Namibia and Botswana to locate crystallized formations created by 30,000 years of urine from a small, furry animal called the rock hyrax. Hyraxes use the same communal toilet area for generations, creating a valuable organic record of environmental changes. Forensic analysis of the deposits reveals the plants the hyraxes ate over the centuries, providing clues to the creatures' evolving environment.



• REBUILDING THE PAST

Reverse-Engineered Blueprints

It has been almost a century since the *Charles W. Morgan,* floating on display at Mystic Seaport in Connecticut, felt the wind in her sails. Restoration experts trying to return the world's last wooden whaler to sea in 2013 needed details of the ship's original design and current condition before relaunching her. The team turned to laser scans and X-rays to provide an intricate picture—with a resolution of an eighth of an inch—of the location and condition of every plank and bolt on the 114-foot ship.

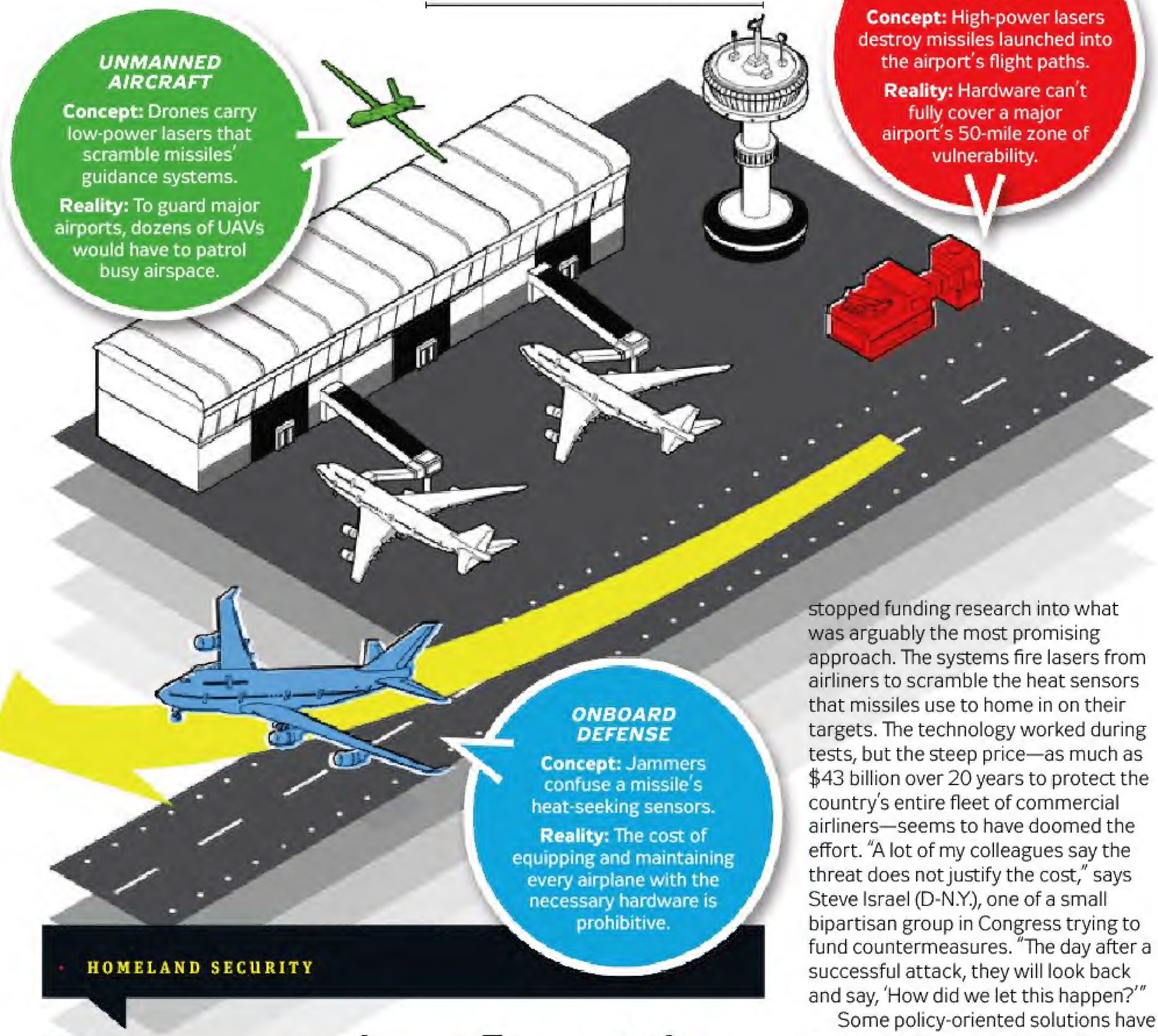
• BIO MATERIALS

Building the Perfect Worm

→ Spider silk is three times as tough as Kevlar and superior to threads produced by commercial silkworms. But spiders don't take well to being "farmed," as silkworms do. So scientists at the University of Notre Dame and the University of Wyoming genetically engineered silkworms to incorporate spider DNA, allowing them to spin high-strength silk. Large quantities of the super-strong silk could be used in better protective ballistic clothing and medical bandages. — *A.H.*

PHOTOGRAPHS COURTESY OF HENRY R. FELDMAN (LASER SCAN); MYSTIC SEAPORT (*CHARLES W. MORGAN*)

ILLUSTRATIONS BY **LEANDRO CASTELAO**



Danger in the Air

THE FEDS SPENT $276 MILLION RESEARCHING GEAR TO PROTECT AIRLINERS FROM MISSILES—BUT NOTHING HAS BEEN DEPLOYED. WHAT HAPPENED? *BY ROXANA TIRON*

In 2002, the world was reminded of an insidious threat to aviation when Al Qaeda operatives shot two shoulder-fired, heat-seeking missiles past an Israeli airliner taking off from Mombasa, Kenya. Later that year, the Bush administration and Congress tasked several U.S. agencies with devising methods to foil such attacks by man-portable air-defense systems, or MANPADS, on civilian airliners. Yet nine years and $276 million later, no U.S. commercial aircraft or airports have been equipped with the defenses.

In 2010, the White House and Congress quietly stopped funding research into what was arguably the most promising approach. The systems fire lasers from airliners to scramble the heat sensors that missiles use to home in on their targets. The technology worked during tests, but the steep price—as much as $43 billion over 20 years to protect the country's entire fleet of commercial airliners—seems to have doomed the effort. "A lot of my colleagues say the threat does not justify the cost," says Steve Israel (D-N.Y.), one of a small bipartisan group in Congress trying to fund countermeasures. "The day after a successful attack, they will look back and say, 'How did we let this happen?'"

Some policy-oriented solutions have emerged as the tech solutions fade. Matt Schroeder, who manages the arms-sales monitoring project at the Federation of American Scientists, points out that Congress is increasing funding for a State Department initiative that has proved successful at securing old foreign stockpiles and destroying 30,000 surplus MANPADS. Unfortunately, he says, China and Iran are now producing new, more potent missiles. The Chinese weapons have been reported in Sudanese arsenals, and Iran's support of terrorist and insurgent groups is leading to renewed proliferation concerns. "The United States has taken many commendable steps," Schroeder says. "But loose missiles are still out there."

CUB CADET
DRIVEN BY INNOVATION FOR 50 YEARS.

CELEBRATING BREAKTHROUGHS AND INNOVATIONS.

Cub Cadet is proud to recognize the supreme dedication exhibited by the winners of the 2010 Popular Mechanics Breakthrough Awards. After all, from day one, Cub Cadet has been driven to create innovative, premium-quality, high-performance and progressive products. It's leadership through innovation.

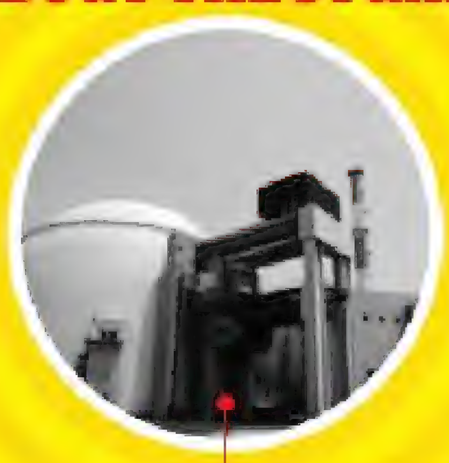
GOT AN INNOVATIVE IDEA OF YOUR OWN?

Cub Cadet is supporting the spirit of innovation. Turn the page or visit cubcadet.com to see how.

Cub Cadet®
FIFTY 50 YEARS
SINCE 1961

DAWN OF CYBERWAR

FOUR THINGS YOU SHOULD KNOW ABOUT THE STUXNET COMPUTER ATTACK



This past summer, cyber-security researchers discovered the first confirmed "in the wild" instance of industrial-control malware. Dubbed Stuxnet, the worm was meant to sabotage computers that run facilities such as electrical plants, oil pipelines and nuclear facilities. Eric Chien, the technical director for Symantec Security Response, whose team spent three months reverse-engineering Stuxnet, explains why it's an ominous milestone. — *GLENN DERENE*

Iran says Stuxnet has infected 30,000 computers, including those at the contentious Bushehr nuclear power plant.

1

It's dangerous. "It became apparent early on that we were dealing with something very, very different," Chien says. "Without exaggeration, someone could die." Stuxnet hides on Windows machines and then injects code into the programmable logic controllers for specialized equipment. The purpose is sabotage. "This could very easily explode a gas pipeline or speed up a centrifuge until it blew up," he says. The only good news is that you needn't worry if it ends up on your PC. Stuxnet doesn't damage conventional home computers, and most commercial antivirus software can easily clean it.

2

We knew it was coming. Cyber-security experts have been warning about the vulnerabilities of industrial control systems for years, and POPULAR MECHANICS published a cover story on the dangers of infrastructure hacking in April 2009. Many of the private companies that run American utilities have been upgrading software and equipment. Newer technology has cyber defenses built in.

3

It's too sophisticated to have been programmed by some punk teenager. There is considerable evidence that Stuxnet is not simply a malicious prank and may be an act of state-sponsored cyber warfare. "Based on the amount of resources needed and the expertise required to put this together, we're talking about some sort of high-value target," Chien says. "This is the first case where we can't say it was probably a hacker in his basement programming this, and it could be a government." That's not counting the apocryphal bit of CIA lore from the 1980s wherein the agency's spooks tricked the Soviets into installing rogue software on components of a Russian pipeline, causing it to explode.

4

It's impossible to determine exactly who did it. In Stuxnet's code, there is evidence to suggest what type of equipment and facility it was aimed at. Some cyber-security experts have concluded that Stuxnet's release was an attack on either the Natanz or the Bushehr Iranian nuclear facility that spread unintentionally. (The United States and Israel maintain the power plants will be repurposed to make weapons, an allegation Iran denies.) But like most malware, Stuxnet is programmed to cover its tracks, so its creators may never be known.

NEW WORLDS

This Planet Is Just Right

Planet hunters say they have found the first exoplanet that could currently have liquid water on its surface and therefore host Earth-like life. "This is our first Goldilocks planet, just the right size and distance from its sun," says Carnegie Institution of Washington astronomer Paul Butler, who co-discovered the planet. "A threshold has been crossed." Gliese 581g is a cosmically cozy 20 light-years away from Earth.

UNDER THE HOOD

Can a 2-stroke engine achieve 100 mpg? Bill Gates thinks so.

Two-stroke engines are usually associated with handheld tools like hedge trimmers. But EcoMotors International says its new two-stroke engine can enable full-size cars to reach 100 mpg on the highway—and it recently received a $23.5 million vote of confidence from Bill Gates and the investment firm Khosla Ventures. The engine has few moving parts: A crankshaft sits between a pair of cylinders, each containing two pistons that move in opposite directions. An electric turbocharger feeds fuel–air mix back into the cylinders, keeping emissions to a minimum. — *A.H.*

PHOTOGRAPH BY GETTY IMAGES; ILLUSTRATION BY LEANDRO CASTELAO

Cub Cadet®

FUTURE VISION CONTEST

CALLING ALL INNOVATORS AND CREATIVE THINKERS!

CUB CADET IS CELEBRATING 50 YEARS of innovation and forward thinking, and you're invited. If you think you have a compelling vision for the future of outdoor power equipment, let the world know! Submit your idea to the Cub Cadet Future Vision Contest for a chance to win **MORE THAN $50,000 IN PRIZES**.

STUDENTS, THERE IS A SPECIAL CATEGORY FOR YOU TO PARTICIPATE. DON'T MISS OUT!

CONTEST RULES: No purchase necessary to enter or win. The Cub Cadet Future Vision Contest. Sponsored by Hearst Communications, Inc.. Begins September 27, 2010 at 12:01 AM (ET) and ends February 15, 2011 at 11:59 PM (ET). Odds of winning will depend upon the total number of eligible entries received. Open to legal residents of the 50 United States, D.C. and Canada who have reached the age of majority in their state of residence at time of entry. Void in Puerto Rico, Quebec Province and where prohibited by law. Sweepstakes subject to complete official rules available at: www.cubcadet.com/futurevision

HOW TO ENTER:

Submit your idea in 200 words or less with an optional simple sketch or rendering at www.cubcadet.com/futurevision

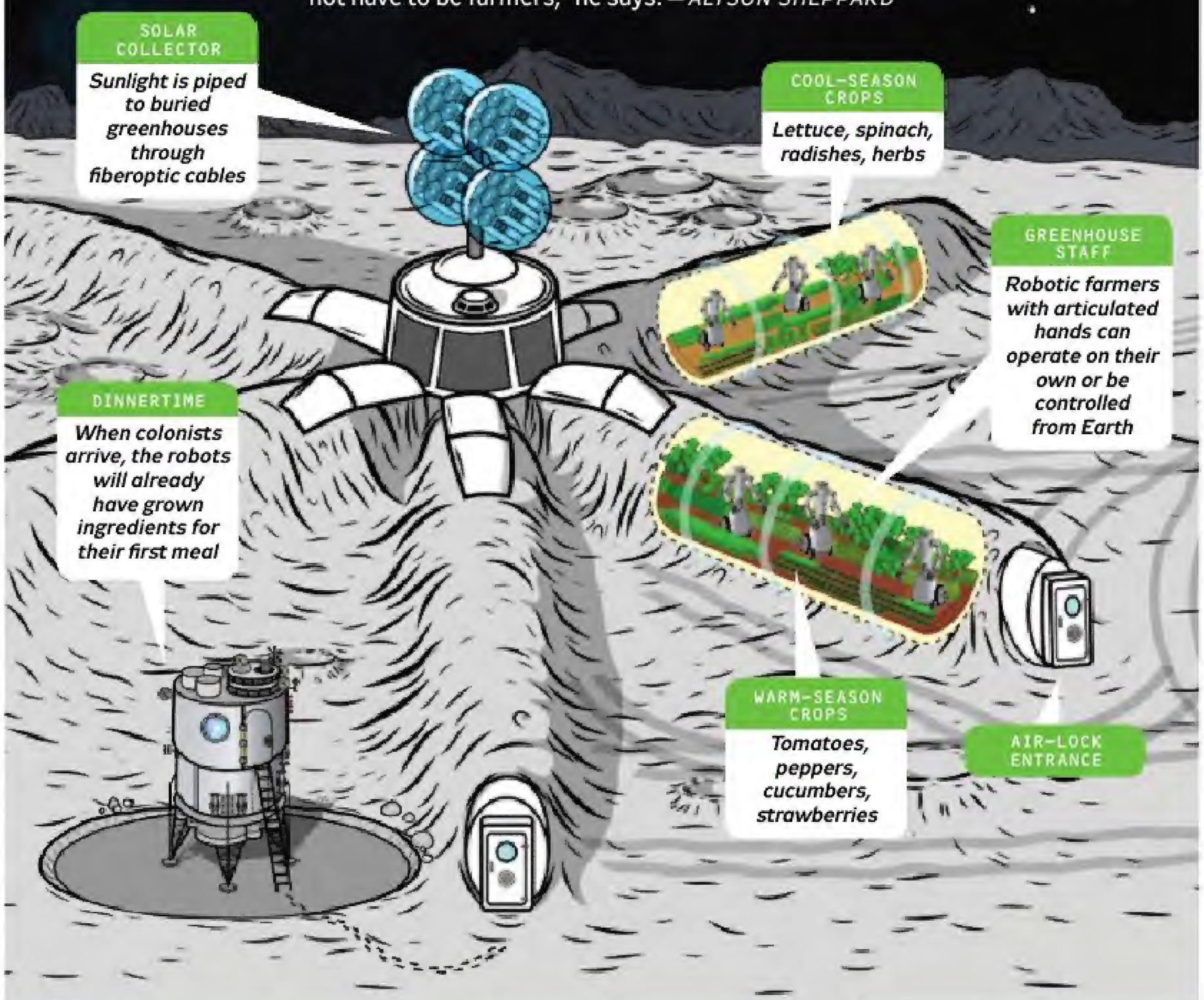
You could be selected as one of 50 semi-finalists, with the chance to win one of 5 grand prizes of $5000 and have your idea featured in Popular Mechanics.

Cub Cadet® FIFTY 50 YEARS | Popular Mechanics

LIVING IN SPACE

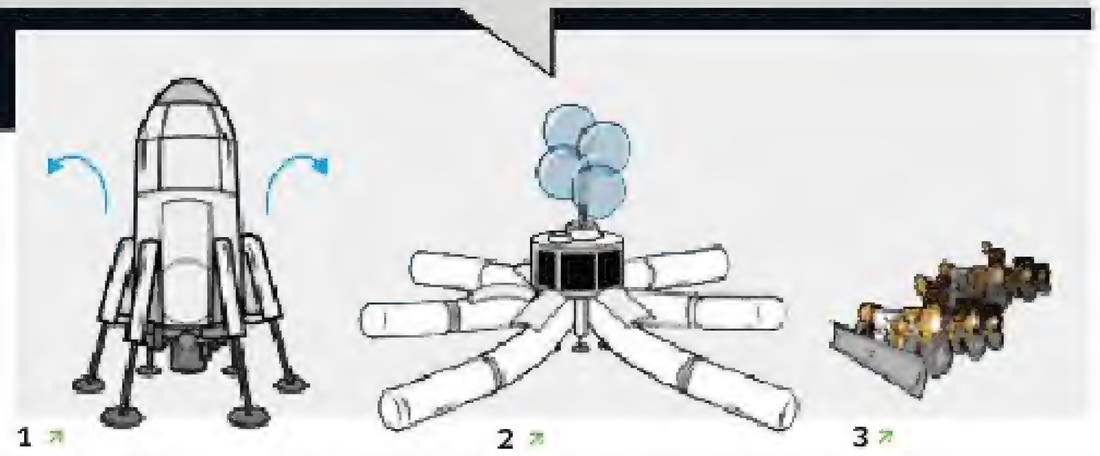
Extraterrestrial Gardening

Teams of scientists around the world—and above it, aboard the International Space Station—are trying to design farms for the diverse environments future explorers could encounter across the solar system. These indoor farms would reduce the need for costly resupply missions while removing carbon dioxide from the air, thus replenishing the astronauts' breathing supply, and could produce about 500 pounds of oxygen a year. Gene Giacomelli, a University of Arizona agricultural researcher and the lead investigator of a NASA-funded growth chamber for the moon, envisions a multiarmed, inflatable greenhouse building staffed with robots that do the bulk of the work. "Astronauts should not have to be farmers," he says. — *ALYSON SHEPPARD*



Lunar Greenhouse: An Automated Setup

The ship holding prepackaged greenhouses lands on the moon 1. The arms deploy and inflate, forming the greenhouses' outer shell 2, and a robotic bulldozer rolls out of one arm and begins to bury the structures 3, protecting them from radiation and micrometeorites.



Space farms will be customized for diverse environments:

MOON

A farm at the moon's poles could tap water ice trapped in craters. Burying the farm buildings will protect them from cosmic rays, micrometeorites and extreme temperatures.
Status: Researchers at the University of Arizona are operating a moon-farm prototype that yields 1100 pounds of edible plants per year.

EARTH ORBIT

Plants in microgravity draw up water and fertilizer faster than roots can process them. Slowly trickling in fertilizer solves the problem and improves plant health.
Status: Russians on the International Space Station developed the technique by growing radishes, peas and barley.

MARS

The planet's protective atmosphere allows structures to be built aboveground.
Status: Italy's space agency is designing greenhouses that can endure Mars's low-pressure, high-carbon-dioxide environment.

ILLUSTRATION BY DIEGO PATINO

Name: X3
Company: EUROCOPTER

Test-Flight Speed:
→ 207 mph (est.)

Engine:
→ Two 2910-hp RTM 322 turboshafts

Payload:
→ 2 crew, 8 passengers

Secret to Speed:
→ Two variable-pitch propellers counter torque from the main rotors, and the stubby wings they are mounted on shoulder 40 percent of the lift at high speeds.

Name: X2
Company: SIKORSKY

Test-Flight Speed:
→ 287 mph, Sept. 2010

Engine:
→ One 1500-hp LHTEC T-801 turboshaft

Payload:
→ 1 crew

Secret to Speed:
→ Four upper and four lower blades made of graphite composites turn in opposite directions to prevent stalls. At high speeds, power is diverted to the pusher propeller in the rear.

Supercopter Showdown

Helicopters have always struggled with a basic limitation—they can't fly too fast. As the aircraft speeds up, the advancing blades of its rotor generate more lift but the retreating blades' relative velocity and lift decrease. This effect saps lift and makes the helicopter unstable. Now the world's two foremost rotorcraft manufacturers, Sikorsky and Eurocopter, have built prototypes that go twice as fast as existing models, potentially redefining a helicopter's role in rescue operations, civilian transportation and military missions. (The Sikorsky version won a 2009 PM Breakthrough Award.) The X2 recently broke the 249-mph helicopter speed record set in 1986 by a modified Westland Lynx. Officially, though, the old record still stands, because the National Aeronautic Association didn't observe the test flight. — *ROB GOODIER*

EVERYDAY PHYSICS Older by Inches

→ **Physicists since** Albert Einstein have calculated that people age faster when they stand a couple of steps higher on a staircase, due to the difference in their distance from the Earth's center, but the phenomenon has been too small to measure in everyday life. Now researchers at the National Institute of Standards and Technology have put numbers to the theory, with two of the most accurate clocks in the world. The clocks tick a quadrillion times per second, using the vibration of a single aluminum ion instead of a pendulum or electronic oscillations. When the two clocks were subjected to unequal gravitational forces, only a foot apart, the higher clock ran faster, just as Einstein and others predicted. Over the course of an average American's 79-year life span, the difference would add up to only 90 billionths of a second. Researchers hope the ultra-precise measurements will help map the Earth's gravitational field, assisting scientists in predicting the behavioral changes of oceans. — *A.H.*

GoPro®

Be a HERO.

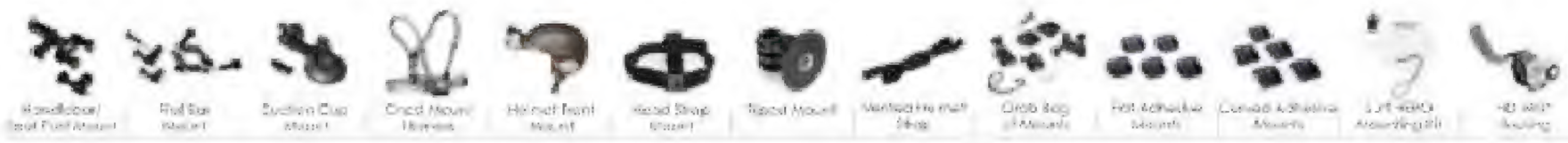
Actual GoPro video shot with the HD Hero. See more at gopro.com

HD HERO
Starting at $179

World's Most Versatile Camera

Wear it. Mount it. Love it.

1080p / 960p / 720p HD Video
Professional Quality Sound
30 and 60 FPS Recording
5MP Auto Photo Mode
Lithium-Ion Rechargeable
32GB SD Compatible
Waterproof 180' / 60m



gopro.com

Upgrade

Full Lithium Jacket

This isn't the first battery-heated outerwear we've seen, but the ***Milwaukee M12 Cordless Heated Jacket ($170 with battery)*** is certainly the first that uses a power-tool battery—a standard Milwaukee 12-volt lithium-ion. Carbon-fiber heating elements are sewed directly into the fabric, allowing the wind- and water-resistant jacket to offer four variable heat settings, from minor warm-up to frostbite-fighting furnace. — *SETH PORGES*

PHOTOGRAPH BY **PHILIP FRIEDMAN**

Bike Bunker

ake it from us: If you leave a motorcycle out in the rain, the seat will be soaked for days. The ***Nomad Ténéré Expedition Tent ($400)*** keeps two campers—and their bike—dry. The ripstop nylon conceals 30 square feet of interior, and the rig adds just 13 pounds to your pack.

DOES IT WORK?

Sharpie Liquid Pencil ($2)

→ Sharpie's new Liquid Pencil sounds like the perfect writing utensil: The company claims its "liquid graphite" combines the erasability of a pencil with the smoothness of a pen and that after drying for a few days, scrawls will magically become permanent. So how does this calligraphic chimera hold up in practice? Unfortunately, it still has a way to go. Unless you bear down with a finger-cramping amount of pressure, writing comes out light and uneven. And despite drying for several days, markings were still fairly easy to erase. This one might need to go back to the drawing board.

Double Dock → It's the little design touches that make us love the ***Altec Lansing Octiv Duo iPhone dock ($100)***. Two side-by-side docking stations allow for simultaneous charging, the remote control magnetically attaches to the back of the dock to keep it from getting lost, and the wedge-like shape fits nicely into counter corners (why didn't we think of that?). And then there's the free accompanying mobile app, which lets you pick and shuffle songs from two docked devices and set the share of songs that play from each.

ILLUSTRATION BY MERCÈ IGLESIAS

ORIGINAL™ BLACK

ORIGINAL™ PLUS

ORIGINAL™ VENT

ORIGINAL™ GRIP

ORIGINAL™ WORKPRO

ORIGINAL™ DRIVE LIGHT

M-PACT® BLACK

M-PACT® FINGERLESS

M-PACT®2 BLACK

FASFIT® BLACK

M-PACT®3

TEAM ISSUE CARBON X® LEVEL 1

21,000,000 new toolboxes a year agree.

Millions of people doing millions of jobs daily. Everyone from race mechanics, construction workers, technicians, military professionals and industrial safety personnel to do-it-yourselfers and everyday mechanics. Our gloves protect their hands and allow them to work faster, safer and cleaner—all while giving them more power and control. They're the perfect tool to get the job done right, every time. Mechanix Gloves. The Tool That Fits Like a Glove.® 800.222.4296 Canada: 604.542.7055

MECHANIX WEAR

mechanix.com

WIND RESISTANT

TEAM ISSUE CARBON X® LEVEL 10

HAPPY HOUR

FABRICATOR

ORIGINAL™ COVERT

M-PACT® CAMO

CG IMPACT PRO MATERIALEX™

UTILITY

IMPACT PRO

CG PADDED PALM

CG HEAVY DUTY

WOMEN'S UTILITY RED

SAFETY M-PACT® ORANGE

SAFETY M-PACT®

GETTING STARTED

Home Brewing

IF YOU CAN COOK, YOU CAN MAKE BEER. DIY BREWS ARE CHEAPER IN THE LONG RUN THAN STORE-BOUGHT SUDS—AND GIVE YOU THE PRIDE OF CREATION. HERE'S HOW TO GET A DIY BREWERY HOPPING. *BY TYGHE TRIMBLE*

→ Beer is more popular now than at any time since Prohibition. While a record 1595 breweries operate nationwide, home brewing is also on the rise. The experts at Dogfish Head, Tröegs, Sierra Nevada and New Belgium (to name a few) offer countless variations on the age-old libation, but making even a single batch in your basement or garage will satisfy your thirst *and* your DIY soul. Here's all you need to know to follow in the footsteps of Adolphus Busch, Frederick Miller and D.G. Yuengling, regardless of your budget.

TIP

USE A LARGE CONTAINER (A WALLPAPER TRAY WILL DO) FILLED WITH SANITIZER TO DOUSE HARD-TO-WASH ITEMS, SUCH AS TUBING.

PHOTOGRAPH BY **PLAMEN PETKOV**

SETUP

Serious about making large batches of beer? Splurge for a propane-powered rig with a three-tiered brew stand. The setup on the facing page, by Indiana-based Blichmann Engineering, costs about $2000 and features a trio of 20- to 30-gallon pots and ***gas burners (1)*** that put out 216,000 Btu per hour. (The high heat quickly boils large amounts of liquid, shaving hours off the brewing process.) More casual or budget brewers can make do with one big pot, heated on a common kitchen stove.

SANITIZE

Yeast and sugar are beer's building blocks—but they're dinner for flavor-spoiling bacteria. So begin by disinfecting all equipment before every batch. Clean the components with hot water and liquid soap and finish the job with a no-rinse sanitizer, such as Star San.

THE MASH

Brewers who want to achieve a highly specific taste should use water to extract sugars from the grains, a messy process called mashing. If you take this route, heat the water and grains (malted barley, wheat and rye are commonly used) to about 155 F in the ***mash tun (2)*** for 1 hour. Needless to say, the types and proportions of grains you choose will influence the flavor of the finished product. As in cooking, you can adjust the recipe, experimenting with different grains to achieve the desired flavor. Heat the water in the ***hot liquor tank (3)*** to 170 F, using a ***thermometer (4)*** to check, then drain the liquid into the mash tun. Next, drain the sugary liquid, or wort, from the mash tun into the ***boil kettle (5)***.

THE BOIL

Add hops—a bitter flavoring agent that balances the sweet grains—to the boil kettle and keep the liquid at a rolling boil for about an hour. Then place a ***wort chiller (6)*** in the liquid to bring it back to room temperature quickly.

ADD YEAST

Drain everything into a ***carboy (7, left)*** or a ***conical fermenter (7, right),*** add the yeast, then put in the stopper and ***airlock (8),*** which act as a buffer between the bubbling beer and contaminants in the air. Filling the airlock with vodka or a flavorless grain alcohol adds another layer of protection against unwanted yeast and bacteria.

BOTTLING

After sitting in the fermentation vessel for two to three weeks, the beer is ready to bottle. First, use a ***hydrometer (9)*** to make sure the alcohol content is in line with your recipe. (If the reading is too low, let the beer sit an extra week in the fermentation vessel.) Next, fill the ***bottling bucket (10)*** with a priming solution, made with ¾ cup of corn sugar dissolved in 2 cups of boiling water. This last meal for the yeast helps carbonate the beer. Finally, use a ***racking cane (11)*** to move the liquid from the fermentation vessel into the bottling bucket. You are now ready to fill the bottles. Move the full bucket to a high surface and attach a hose and ***bottling wand (12)*** to the spigot. Fill the bottle halfway up the neck and set it aside. Use a ***bottle capper (13)*** to seal the bottles with tops, and then let the beer rest in a cool place for the final two- to three-week fermentation, which helps make the beer bubbly. At last, the fun part: Chill, pop open and enjoy!

Beer Here!

We've compiled some of our favorite recipes at ***popularmechanics.com/beerrecipes.*** Want more? Here are three great recipe sites:

→ ***thebrewingnetwork.com*** This full-service destination features an impressive recipe roster.

→ ***homebrewtalk.com*** A well-trafficked Web forum for beer alchemists to share their formulas.

→ ***beerrecipes.org*** This searchable database has more than 1100 beer recipes.

TIP

YOU DON'T NEED GRAIN TO MAKE A QUALITY BREW. USE PREPACK-AGED MALT EXTRACT AND YOU CAN SKIP THE MASH AND GO STRAIGHT TO THE BOIL. EVEN CONNOIS-SEURS WON'T BE ABLE TO TELL THE DIFFERENCE.

TIP

USE A METAL FERMENTER, LIKE THIS 15-GALLON ONE, FOR BIG BATCHES, OR A GLASS CARBOY FOR SMALLER AMOUNTS.

Set-Top Showdown

Internet-enabled TV-set-top boxes have been around for years, but the latest batch are the first that really make us want to cut our cable. They're all incredibly easy to use, cheaper than a month of premium cable and set up to deliver Netflix's huge stash of streaming TV shows and movies, in addition to their own unique offerings. But how do you choose the best box for you? Well, view it as a modern update to an age-old conundrum: Do you go for the à la carte menu or the all-you-can-eat buffet? If you prefer a piecemeal plan, there's ***Apple TV ($99)***, which offers 99-cent "rentals" of shows from select networks—so you pay for only what you watch. A buffet fan? The newest line of ***Roku Digital Video Players ($60 to $100)*** are some of the first TV-connected devices that can stream shows from Hulu's $10-per-month premium service.

Parental Control

→ Giving a child access to your primary PC is risky—not only is a huge chunk of the Internet inappropriate for, well, everybody, but a few clicks (or a single drop to the floor) can be all it takes to turn that SpongeBob game into a heap of deleted files. The ***Toshiba Satellite L635 Kids' PC ($500)*** is equipped with a porn-blocking browser, loads of kid-friendly software and a crumb-proof keyboard that can easily be wiped clean.

Smooth Driver

→ When it came to designing the ***Dewalt DCD710S2 ⅜-Inch Drill/Driver Kit ($160)***, ergonomics were key: The design team went through 19 prototype handles before settling on the optimum grip. The obsessive perfectionism shows in the final product, which is one of the most comfortable drill drivers we've ever held. Other clever design touches: a three-jawed chuck, a ring of LEDs that light up the bit and a sliding flat battery that lets the tool stand upright.

WEBSITE PLANS ON SALE!

ALL WEB HOSTING PACKAGES JUST: **$3.99 per month***

Hurry – offer ends 12/31/2010!

For the first 3 months!

Whether you're a beginner or a professional, 1&1 offers a full range of website solutions to suit your needs. For a limited time, we're offering all web hosting packages at one incredible low price. Website building tools, unlimited traffic, and search engine marketing dollars are included with all packages.

Go to www.1and1.com to choose your package!

DOMAIN OFFERS:

.info only $0.99 first year* .com only $4.99 first year*

- Free Web Marketing Tools
- 90-Day Money Back Guarantee
- 24/7 Toll-Free Support

1&1®

MEMBER OF united internet

Call 1-877-GO-1AND1 or visit us now

www.1and1.com

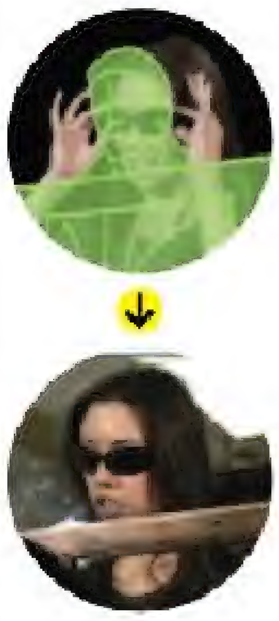
*Offers valid through December 31, 2010. 12 month minimum contract term applies for web hosting offers. Setup fee and other terms and conditions may apply. Domain offers valid first year only. After first year, standard pricing applies. Visit www.1and1.com for full promotional offer details. Program and pricing specifications and availability subject to change without notice. 1&1 and the 1&1 logo are trademarks of 1&1 Internet AG, all other trademarks are the property of their respective owners. © 2010 1&1 Internet, Inc. All rights reserved.

Portable 3D → The ***Samsung BD-C8000 ($500)*** is touted as the "world's first portable 3D Blu-ray player." And it is—as long as it's plugged into a 3D TV (the attached screen is strictly 2D). Want pure on-the-go 3D viewing? We wouldn't be surprised if the next-gen update has you covered.

Smoke Monster

he BBQ pit is a relatively simple contraption. As long as it can contain smoke, it can come in just about any shape or make—from a hand-welded scrap-metal box to a multimaterial work of art. The ***Thousand Oaks Whiskey Barrel Bar-B-Q Pit ($950)*** sits firmly in the latter category—it is handmade from a retired whiskey barrel lined with metal (you know, to keep the thing from catching fire). Sure, it's pricey, but it's also the classiest tailgating centerpiece we've ever seen.

Movie Hero
→ Last year's *Yoostar* game—which used a webcam and a green screen to digitally insert players into movie scenes—was a great idea plagued by a flawed execution. By piggybacking on Microsoft's Kinect gesture-control interface for the Xbox 360 or the Sony PS3's camera attachment, ***Yoostar 2 ($60)*** fixes its predecessor's shortcomings. The cameras accurately place players in the action without a green screen, and the movie-scene selection is now much better. Playing the original *Yoostar* could be stressful. Playing *Yoostar 2* is just plain fun.



Is This the Return of Video Calls?

→ VIDEO CHATS ARE MAKING THE MOVE FROM THE PC TO THE TV. BUT ARE WE WILLING TO PAY?

It's been more than 45 years since AT&T's Picturephone made a splash at the 1964 New York World's Fair, but consumers are still leery of a phone that requires them to mind their appearance. And while Skype, Google Talk and iChat users now routinely video call each other, the practice is largely confined to the computer (and, we suppose, the video-call-enabled iPhone 4). So is video calling ready to make the leap to the couch? Cisco sure hopes so. For years, the company has been perfecting corporate telepresence, with expensive, high-resolution setups that allow CEOs to beam into board meetings. With the new ***Cisco Ūmi Telepresence System ($600)***—which combines a TV-mounted 1080p HD camera with an array of microphones—the company has brought the tech into the living room. In practice, Ūmi is an extraordinary technology—the lag-free, high-resolution video is really all we could ask for. But in a world where Skype video calls are free (and available in the living room through the very similar, if not quite as impressive, Skype TV service), it's hard to imagine many customers shelling out Ūmi's $25-per-month service fee, on top of the $600 base price. And while the service is compatible with Google Talk, the full HD experience really requires both parties to have the expensive Ūmi setup. In other words, even if you splurge for the service, you might have a hard time actually finding somebody to use it with.

DOWNGRADE

Clicker ($24)

→ The convergence-gadget graveyard is populated with a Sky Mall catalog's worth of pointless products. Still, the idea of a bottle-opening remote makes sense, even if it is a bit patronizing (most men who don't live in sitcoms aren't *that* lazy or beer-reliant). So the Clicker's problems lie in its execution: It violates a central tenet of product convergence by sacrificing feature quality for quantity. The bottle-opening slot is made from cheap plastic that began to chip after a single soiree, and the no-frills universal remote feels like a relic from the '90s. So while we salute the idea of making the bottle opener a feature in, well, everything, we'll pass on this remote.

Printer Tablet → The detachable touchscreen display on the ***HP Photosmart eStation All-In-One ($400)*** printer/copier/fax machine/scanner can access apps and the Web—without the need to boot up a PC.

PHOTOGRAPH BY BEN GOLDSTEIN/STUDIO D (CLICKER)

ILLUSTRATION BY **DIEGO MORALES**

COMING IN DECEMBER

The January PopMech App

Each month, the Popular Mechanics team takes every word and picture of the print issue, optimizes it for the iPad experience and adds interactive functionality to best enhance the individual stories. The result? Pop Mech: a must-download app! This month, don't miss our Digital Hollywood coverage.

Available on the App Store

PREMIUM CONTENT INCLUDES

VIDEO & ANIMATIONS THAT BRING CONTENT TO LIFE

CONSTANTLY UPDATED NEWSFEED

ROTATING 3D VIEWS

BOOKMARKING AND SHARING TOOLS

AND MUCH MORE!

OFFICIAL JAN. APP SPONSORS

Allstate. MOTORCYCLE

Digi-Key CORPORATION

www.digikey.com

New Cars

++ TEST DRIVEN

Swedish Sportster

2011
VOLVO S60

BASE PRICE
$38,550

Volvo is best known as a safe but somewhat stodgy brand. But now, its new Chinese owner, Geely Automobile, intends a shift to the sporty end with the new S60 sedan. The hardware—a 300-hp turbo straight six engine, a six-speed automatic gearbox and standard all-wheel drive—certainly sounds promising, and the aggressive styling should raise eyebrows. In Oregon's hill country, the S60's handling proved lively. The suspension controlled the wheel's movements and exhibited sharp, responsive turning and considerable grip. We left on the stability-control system and found it to be a gentle hand that kept the car on line without dramatic interventions. The engine boasts 325 lb-ft of torque at just 2100 rpm, so it was always quick to respond to our right foot. The supportive and well-bolstered seats stayed on message yet still revealed an appreciated plushness. The S60 is an entertaining car with more spunk than any Volvo in recent memory.

— BASEM WASEF

2010 Harley-Davidson Forty-Eight

BOBBY TWIN

+ The new Forty-Eight is yet another Harley riding on the exhaust pipes of the past. But while retro is getting a tad stale these days, in this case we dig it. Harley's latest harks back to the bobber custom bikes of the '40s and '50s, with laced wheels, under-bar mirrors, a chopped front fender and a stretched-out riding position. The classic 1.2-liter V-twin packs 79 lb-ft of torque at 4000 rpm and has a cool black patina. On the seaside pavement ribbon better known as the Pacific Coast Highway, the Forty-Eight felt light, easy to steer and torque-rich with each twist of the grip. The clutch and gear changes required just the right amount of effort, reminding us that, despite the Forty-Eight's compact size, there's still a big twin beneath the frame rails. It's a rough and raw homage to the past that looks authentic and provides an unconventional experience well worth the $10,499 price tag. — *BEN STEWART*

Haute Hatch

The stylish 2012 Audi A7 Sportback (estimated to start at $60,000 when it arrives later this year) easily wins the four-door-coupe beauty contest against competitors like the BMW 535i GT and Mercedes-Benz CLS. Dieting helped—the A7's doors, hood, hatchback and front fenders are all aluminum. Under the lightweight skin is an athletic new platform that uses high-strength steel to make the hatchback's body shell both stiffer and lighter than the A6 sedan's. Thanks to Audi's Quattro system, all four wheels share power from a 3.0-liter supercharged V6 that produces 300 hp and 325 lb-ft of torque. An eight-speed Tiptronic transmission combined with a center differential distributes that power to all four wheels (a seven-speed DSG will be available on S-line trim), and there's traction and stability control to prevent wheelspin. Audi's sport differential, which uses two multiplate clutches to distribute torque across the rear axle, is optional. Best of all, the A7 is as fast as it looks; it'll hit 60 mph in 5.5 seconds. — *ANDREW ENGLISH*

2012 Audi A7 Sportback

2011 Ford F-150

+ To prove the robustness of the F-150's twin-turbo V6, Ford installed the engine in this off-road racer.

BOOSTED PICKUP

+ For 2011, Ford has revamped its pickup with fresh engines—including a twin-turbo V6. The decades-old 4.2-liter "Essex" V6 has been swapped out for a 3.7-liter DOHC 302-hp V6. There are two V8s, a 5.0-liter with 360 hp and a 6.2-liter V8 that produces 411 thundering horses. Naturally, the new engines are more efficient, and they're all available with a six-speed automatic. The base V6 should return up to 23 mpg on the highway. That's noteworthy, but the twin-turbo 3.5-liter V6 is the most interesting. Similar versions of this motor are used in Ford cars, but it's been toughened for pickup duty with stronger main bearings and an upgraded cooling system. The turbo V6 packs 365 hp and can tow more than 11,000 pounds. Plus, it promises 5 percent better fuel economy than the 5.0-liter V8, a claim we're eager to test. — *REX ROY*

GIVE THE BRIEFCASE THAT WILL NEVER GO OUT OF STYLE


170 Piece Set


150 Piece Set


123 Piece Set


85 Piece Set

Visit StanleyGiftCenter.com

STANLEY® STORAGE MAKES THE PERFECT HOLIDAY GIFT

Try a new gift idea this Holiday Season. The Stanley® line of mechanics tool sets are sure to stay in style longer than any other gift. Whether your special someone likes to tinker with cars or tackle DIY projects, there's a set to suit anyone's needs perfectly. Each set features chrome vanadium for added durability, a rugged carrying case for convenient storage and a lifetime warranty. They make the perfect holiday gift.

STANLEY®

stanleytools.com

2014 VW Electric Golf

Volting VW

The parade of electric cars started by the Nissan Leaf continues to gain entrants. In roughly three years, VW will offer an electric version of the Golf. We took a drive in an early prototype that appeared more complete than the usual engineering mule. The 26.4-kwh lithium-ion battery pack is made of 180 cells, which are distributed in three places around the car: under the trunk floor, under the rear seats and in a central under-floor tunnel. Climb in and you'd struggle to see any difference between this interior and that of the standard Golf. In place of the standard tachometer and fuel gauge, VW has brilliantly changed its analog instruments to show power usage in kilowatts and the charge left in the battery pack. Like all electric cars, in which peak torque is available from 0 revs, the Golf is quick away from the lights. Even with three adults on board, the 114-hp motor felt strong and responsive up to about 50 mph—that's when the acceleration started to tail off. VW estimates the range will be about 85 miles, which should be plenty for daily use. *— ANDREW ENGLISH*

SEDAN OPTIMUS

+ The third generation of Kia's midsize Optima ($18,995), which competes with the perennially best-selling Honda Accord and Toyota Camry, shares platforms with the 2011 Hyundai Sonata; both have a 110-inch wheelbase and offer a similar feel, thanks to their identical strut front and multilink rear suspensions. Like the Sonata, the Optima is available with three different powertrains, including a high-mileage hybrid that arrives early this year. For now, there's a 200-hp 2.4-liter direct-injected four-cylinder engine with a six-speed transmission (manual or automatic) that delivers 24 mpg city and 34 mpg highway. By about the time you read this, an SX model will have debuted with a 274-hp 2.0-liter turbocharged four-cylinder paired to a six-speed automatic. While the car's appearance is athletic, its dynamics cater to the mass market (in other words, the suspension is tuned for comfort). However, the midlevel Optima EX we drove exhibited a good balance between a soft ride and buttoned-down cornering. The SX's firmer ride—and meatier 225/45R18 tires—will no doubt be a better match for the sporty packaging. *— BEN STEWART*

2011 Kia Optima

2011 Lincoln MKZ Hybrid

FANCIER FUSION

+ Lincoln's upmarket version of the Fusion Hybrid adds in a luxury feel without sacrificing fuel efficiency. Just like the Fusion's, the 2.5-liter engine employs the late-intake-valve-closing Atkinson cycle to increase efficiency. That engine, combined with the electric motor, develops a respectable 191 hp. The EPA estimates 41 mpg city and 36 mpg highway, which bests the Lexus HS 250h. Even with total disregard for the car's eco gauge, we managed to attain more than 38 mpg under mixed driving conditions. In base trim, the MKZ Hybrid will cost $35,180—exactly as much as the base V6 model. For that, you get perforated, heated and cooled leather seats, and the topnotch Sync telematics system with a large LCD touchscreen that controls everything from hands-free phone calls to the climate and audio systems. The smallest Lincoln serves up a quieter, roomier cabin, but the interior could use some attention: Black plastic makes its familial roots a bit too obvious. *— JAMES TATE*

WIN BOTH TAX FREE*

And Help Our Wounded Troops

Restored 1969 Boss 302 Mustang
– A Rare and Collectible Classic –

2012 Patriot Edition Boss 302 Mustang
– One of a Kind Future Classic –

Serial #1 of 1

THE WORLD'S ONLY MATCHING PAIR OF 1ST AND 2ND GENERATION BOSS MUSTANGS!

Enter at **winthemustangs.com** or call **877-700-U WIN** (877-700-8946)

2011 Mustang Dream Giveaway

A Dream Giveaway® sweepstakes

YES, I WANT TO HELP THE TROOPS AND WIN BOTH CARS!

COMPLETE CREDIT CARD INFO OR MAKE CHECKS PAYABLE TO:

☐ VISA ☐ MasterCard ☐ DISCOVER ☐ American Express

Healing Heroes Network, Inc.
P.O. Box 6066
St. Louis, MO 63139-0066

Name: _____ Phone: _____

Address: _____

City: _____ State: _____ Zip: _____

Card # _____ Exp: _____ Security Code: _____

☐ Email: _____
No charge for email – receive your tickets and updates fast and FREE!

☐ Mail Tickets Add $1.95 mail/processing for tickets by mail

☐ I HEREBY CERTIFY THAT I AM 18 YEARS OF AGE OR OLDER

Credit Card Orders may be FAXED TO: 815-364-2999

YOUR DONATION BENEFITS

HEALING HEROES NETWORK

A 501(c)(3) Charitable organization
www.healingheroes.org

Use Promo Code: PM0111

☐ $3	1 TICKET	☐ $200	240 TICKETS
☐ $10	5 TICKETS	☐ $300	360 TICKETS
☐ $20	15 TICKETS	☐ $500	600 TICKETS
☐ $50	40 TICKETS	☐ $750	900 TICKETS
☐ $100	100 TICKETS	☐ $1000	1200 TICKETS

Donation Amout $ _____

Mail/Processing: Add $1.95 U.S. mail or $4.95 non-U.S. mail ($0 for email)

TOTAL AMOUNT ENCLOSED: _____

Please allow 2 to 3 weeks for mail delivery

If you are aware of a wounded hero injured after September 11, 2001, in need of medical services not being provided, or if you are a medical provider willing to join the network, please contact Healing Heroes Network directly at 877-470-HERO (4376) or visit www.healingheroes.org.

No Purchase, Contribution, Donation or Payment Necessary. Tax-deductible to the fullest extent of the law. 2011 Mustang Dream Giveaway Sweepstakes starts on November 1st, 2010 and ends at 11:59 p.m. EST on July 4th, 2011. All entries must be received and processed by 11:59 PM EST, on July 4th, 2011. Sweepstakes is open to residents of the U.S. and Canada, (except Quebec) and other countries and U.S. territories and possessions only where offered and permitted by law, age 18 and older. Void where prohibited. Odds of winning equal to one divided by the total number of tickets issued. For entry and official rules visit www.winthemustangs.com. Sponsored by Healing Heroes Network, Inc., 31640 US 19N, Ste 2, Palm Harbor, Florida 34684.* "Tax-Free" applies to IRS withholding tax requirements only, all other federal, state, or local taxes remain winner's responsibility.

Ford Oval and Mustang are registered trademarks owned and licensed by Ford Motor Company.

Driving the X Prize Winners

Three weeks after the Progressive Insurance Automotive X Prize handed out $10 million to three winners, PM took

Even the door of the Edison2 Very Light Car reminds you of its otherworldliness; it's like a huge carbon-fiber potato chip.

That portal illustrates what we've long known—light weight translates into good mileage. The Edison2 won the mainstream class, the toughest of the three Automotive X Prize categories. That means room for four and a 200-mile range. It also had to meet or beat current emissions requirements and have a chance at passing crash tests. Running on E85, the VLC returned the equivalent of 102.5 miles per gallon.

Start the engine and the gauges on the steering wheel come to life. The 40-hp 250-cc Yamaha single whirs audibly from its mounts at the rear of the car. There's no sound deadening or even a decent radio to muffle the racket. It's hot inside, too, owing to the absence of usable air conditioning or even roll-down windows. But those features add weight—as do batteries, which is why the VLC isn't electric—and the Edison2 tips the scales at just 830 pounds, a quarter the heft of most cars. There's barely an inch between my shoulder and my passenger, a consequence of the car's minuscule body width, which combines with the slippery shape for an astonishing 0.16 coefficient of drag. The car requires just a few horsepower to cruise at 60 mph, less than a third of what your neighbor's Honda Accord needs to travel at the same speed.

The VLC was designed by race engineers, a fact that's immediately evident on the road. The unassisted steering is light and direct, and the shifter positively engages each gear of the sequential five-speed manual. Acceleration is acceptable, if not exactly brisk. In terms of feel, it mimics a small-bore open-wheel race car—responsive, eager to change direction and actually kind of fun. The Edison2 team invented a new suspension system that fits entirely inside the car's outrigger wheels. These mount on extruded aluminum beams that run transversely across the width of the car at the front and the back. In the event of a crash, they're designed to peel off dissipating energy while the steel-tube chassis deflects away from the impact—a novel idea that has yet

EDISON2 VERY LIGHT CAR

SPECS

TYPE: 4-passenger with gas engine
LENGTH: 167 inches
WEIGHT: 830 pounds
HORSEPOWER: 40
MPGe: 102.5

PHOTOGRAPHS BY **BRENT CLARK**

the Edison2 Very Light Car and the Li-Ion Motors Wave II for exclusive test drives. BY DAN CARNEY

LI-ION MOTORS EVI WAVE II

SPECS

TYPE: 2-passenger EV
LENGTH: 152 inches
WEIGHT: 2150 pounds
HORSEPOWER: 58
MPGe: 187

to be tested. But it's a bumpy ride, owing to the maximum of 4 inches of suspension that could be fitted into the 15-inch wheels. Brad Jaeger, Edison2's R&D director, said that a design using 18-inch wheels and 7 inches of travel is in the works.

While Edison2 is currently looking for a manufacturer to produce and sell a version of the VLC, Li-Ion Motors is already taking orders for its winner, the Wave II. The company says the all-electric car will cost $39,000 and should be available by next year. In the side-by-side alternative class, the Wave II proved astonishingly efficient, returning the equivalent of 187 mpg and beating the slick Aptera 2e, thanks in part to proprietary battery technology. It also appears to have an effective method for quickly recharging those batteries, claiming it can fast-charge the pack while maintaining the temperature to within a few degrees, lengthening its life. The company would not go into specifics, so it's fair to say that the batteries and charging system—as well as the Wave II's crash-worthiness—await further testing.

Like the Edison car, the Wave II makes sacrifices in the name of miserly energy use. The electric motor smartly whips the car up to speed, but the power trails off dramatically once it reaches highway cruising velocity. Without an internal combustion engine, there's just a whir from the driveline, but it isn't quiet inside. The chassis groans and the springs creak as this future ride crashes over bumps. The body covering the steel-tube chassis makes for a slippery 0.16 drag coefficient, but it lacks a rear window, and the video cameras used for rearward vision aren't terribly helpful.

According to Ron Cerven, the Li-Ion Motors team leader, many of those issues are the result of the car being optimized for the contest. Production models will have a 30 percent larger battery pack, a more powerful motor and refinements that aim to shed the car's kit-car feel. All those features, however, will negatively affect its efficiency.

It's hard to imagine even small-volume niche vehicles existing without convenience features. Li-Ion's struggle will be to civilize its car so it's a viable alternative to Nissan's all-electric Leaf. The struggle for all of us as we face a future using less carbon-based fuel will be to realize that we may not be able to have it all. That lesson could be the X Prize's most important legacy.

Jaguar C-X75

The Turbine Supercar

Combining efficiency with high performance, Jaguar's C-X75 concept car offers a fresh take on an old technology. *BY LARRY WEBSTER*

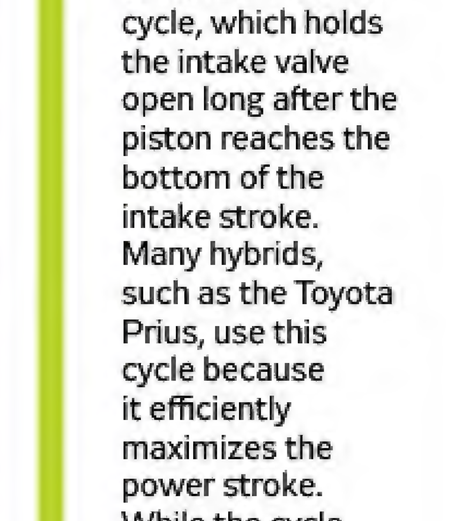
Turbine engines have been tried before in cars—Chrysler built 50 turbine cars in 1963—but slow throttle response, poor mileage and other maladies proved the engine unfit for automobiles. The powerplants, however, are again being considered—this time as small backup generators for electric cars.

At last year's Paris Motor Show, Jaguar debuted the stunning electrically powered C-X75 concept car. It's a typical auto-show fantasy machine—four in-wheel electric motors supply nearly 800 hp and more than 200 mph. But its two turbine-powered backup generators—which spin at 80,000 rpm—signal a new approach to curing range anxiety.

"Each microturbine on the C-X75 produces 90 horsepower and weighs just 80 pounds, including the generator," says Dr. Anthony Harper, Jaguar's head of research and advanced system engineering. "A similarly powered piston engine would weigh three times as much."

For an electric car, lowering the weight means extending the electric-only range, making turbines attractive even considering the engine's inherent drawbacks—which are substantial. Turbines aren't as efficient as piston engines, and their exhaust is exceedingly hot, noisy and difficult to treat for emission requirements.

Jag's concept is not the first. In 2009, Richard Hilleman, creative director at video-game maker Electronic Arts, built a plug-in series hybrid with a Capstone microturbine engine. It's been 50 years, but the era of the turbine car may have finally arrived.



SKY-HIGH EFFICIENCY

Smaller, turbocharged engines are one way to increase engine efficiency by 8 to 10 percent, but the extra hardware is expensive. Mazda aims to achieve similar gains with its less complex ***Sky-G naturally aspirated 2.0-liter four-cylinder.*** It uses direct injection, a lofty 13:1 compression ratio and a wide-range intake-cam adjustor. Under light loads, that cam mechanism allows the engine to run the Atkinson cycle, which holds the intake valve open long after the piston reaches the bottom of the intake stroke. Many hybrids, such as the Toyota Prius, use this cycle because it efficiently maximizes the power stroke. While the cycle increases efficiency, it lowers maximum power, a trait hybrids accommodate with electric boost. The Mazda engine, however, switches to the regular Otto cycle at high loads. The engine will first appear in 2012 in the Mazda3, which should achieve mid-40 highway mpg. —*J.T.*

Regrettably, in last November's issue, we published a picture of the 2010 Honda Odyssey, not the new 2011 model as intended. Here's the correct shot.

Cars on Autopilot

With the arrival of Google's autonomous vehicle, is the time for driverless cars finally here? *BY LARRY WEBSTER*

Google surprised the automotive world with the recent announcement that it has produced a fleet of driverless Toyota Priuses. The company claims its cars have driven themselves 140,000 miles—with a driver in the seat, just in case—making these the most thoroughly tested autonomous cars to date. Considering that the first DARPA competition in 2004 ended without any of the competitors finishing the 150-mile course, the technology is moving fast.

Partially autonomous cars are closer to the market than you might think—in fact, they're already here. The 2011 Infiniti M56 uses forward-looking radar to track the car ahead, and cameras to detect lane boundaries. It automatically maintains the gap with the car in front—using brakes and throttle—and can brake just one wheel to center an errant car back in its lane.

"We're building the blocks for autonomous vehicles," says Nady Boules, director of GM's Electrical and Controls Integration lab and a member of the team that won the 2007 DARPA competition with a driverless Chevy Tahoe. "In 10 years we'll have the technology for autonomous vehicles well in hand."

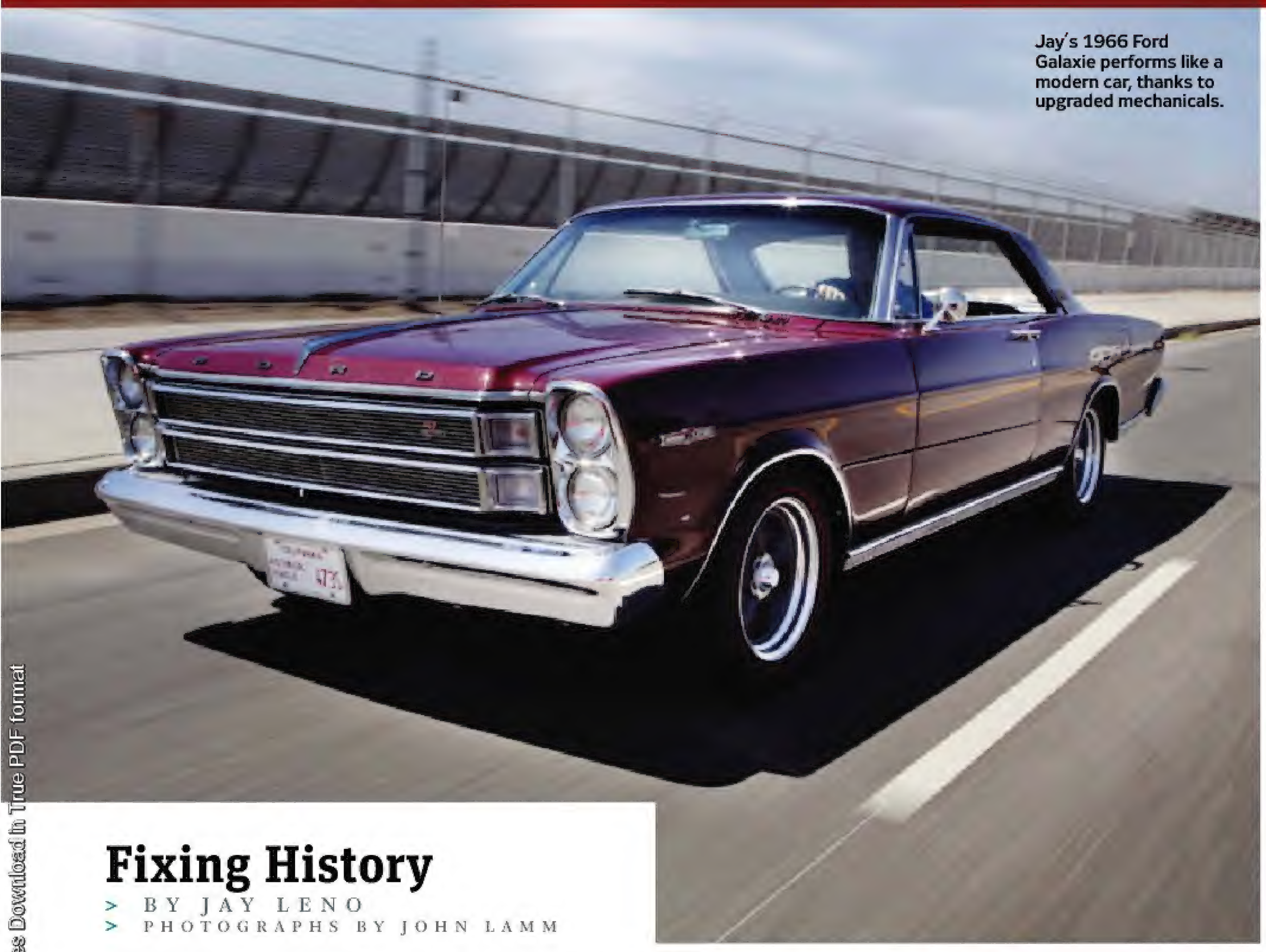
The trick will be producing the required hardware that's robust and cheap enough for a reasonably priced car. Sure, Google's fleet is out there on autopilot, but the jump from prototypes to self-driving production cars is a Grand Canyon–size leap. Current commercial GPS is only accurate to a couple of yards, and it needs to be down to the inch level. The laser and radar sensors and vision systems that determine the car's position and the obstacles around it require higher resolution and must get smaller in size.

Until those improvements arrive, cars will take control only gradually. Automated steering is on the horizon—electrically assisted steering already compensates for road crown and crosswinds—and will enable computer-controlled lane changes and accident avoidance. The challenge for automakers will then be keeping the driver engaged. "Until the car is fully autonomous, the driver is ultimately responsible," Boules said. "Part of the research is figuring out how to keep the driver from taking a nap."

Vehicle-to-vehicle (V2V) technology that broadcasts a car's speed, position and braking can increase safety, but V2V is only useful if it's in every car on the road, which is unlikely. If V2V were to become ubiquitous, however, autonomous cars could shed some of the sensors, reducing their cost.

The safety benefits of autonomous cars are obvious, but they could also increase efficiency and reduce congestion, goals Google says it's pursuing. Maybe one day we'll be able to surf the Web on the way to work.

Google tested a fleet of seven autonomous automobiles over 140,000 miles—with a driver ready to take the wheel. Much of the computing hardware (above) fit under the rear cargo area.



Jay's 1966 Ford Galaxie performs like a modern car, thanks to upgraded mechanicals.

Fixing History

> BY JAY LENO
> PHOTOGRAPHS BY JOHN LAMM

HORSEPOWER BY ITSELF IS WICKED FUN, but it can bite too. Consider this: One day I'm driving my 1966 Hemi-powered Dodge Coronet up a winding road in Coldwater Canyon, near my home in Los Angeles. A car pulls up behind me. I decide I'm gonna have a little fun with this guy. With 425 hp, my old Dodge—one of just 339 made with the Hemi V8—has more than enough poke to make this guy disappear from my rearview mirror. So when I come around a corner, I give it a little extra gas. Little do I realize the road is damp. The Coronet goes *errrupp* and spins a full 180 degrees. Now I'm looking at my pursuer head-on. He hits the brakes and the horn and stops with our two grilles about 6 feet apart. I wave and sheepishly say, "Sorry!"

If I'd been in a modern Audi S4 or a Mustang 5.0, I could have been going 30 mph faster and not even hinted at spinning. While the old Dodge has more power than either, the rest of it is pure 1966—leaf-spring rear suspension, skinny bias-ply tires and no power steering or brakes. My Coronet is just like the rest of the '60s-era muscle cars in that it has tons of power but doesn't stop or go around corners very well. We all loved the flaws, but the fact is, these cars aren't very safe. That's why I'm a firm believer in upgrading old steeds with modern components.

Above: At a quick glance, Jay's Galaxie appears original, but underneath lies a fuel-injected Jack Roush V8, six-speed gearbox and powerful disc brakes (left).

It's called restomodding. You take an old car and modernize it with an updated engine, suspension, brakes, tires and electronics. And if you restomod the right way, you can revert back to stock at any time. I've been subtly updating my cars for years. Take my two 1925 Doble steam cars. They weigh 6000 pounds and move pretty well but only have rear brakes. That's insane. I put brake drums on the front, with Corvette disc brakes hidden inside them. Now I can comfortably drive my Dobles, because they reliably stop.

I went much further with my just-restored Ford Galaxie. While it looks completely original, it's an all-new car underneath. The suspension now moves with improved trailing arms, a Panhard rod to limit rear-axle sway, oversize antiroll bars, beefed-up mounting brackets and stiffer, polyurethane bushings, all from a suspension company called Hotchkis. The sloppy recirculating-ball steering was replaced with a precise rack-and-pinion setup. Wilwood cross-drilled and vented disc brakes grace all four corners. In the engine room, there's a fuel-injected 511-cubic-inch Jack Roush V8 backed by a Tremec six-speed gearbox. We wrapped the old pieces in paper and put them on a shelf in case we ever want to return the car to its original condition.

Thanks to the new hardware and upgraded tires, this old Ford gets far better fuel economy, and it really handles. By contrast, when I used to drive my dad's '66 Galaxie 7 Litre, which I wrote about in this column (Oct. 2009), if an exit ramp sign read "45 mph" and I was doing 46, I'd never make it. Now I've got plenty of breathing room.

Restomods are more popular than ever, so there are bolt-on parts for a wide range of vintage cars. GM recently began offering a 430-hp crate engine with emissions-compliant fuel and exhaust systems. You can drop it into your hot rod and pass California's stringent emissions inspections.

These improvements aren't limited to the mechanicals. Vintage Air makes air-conditioning systems that can be adapted to almost any car. Most older cars have acres of room under their hoods, and a new compressor isn't much bigger than an alternator. Over time, a/c will ensure your interior doesn't get damaged, because you're no longer driving with your windows down. I also like to use Dynamat insulation, which sticks to the floor pan underneath the carpet. It's amazing the difference this lightweight material can make. The clatter, the vibration and the heat that used to fill the cabin—that's all gone.

If you install a 12-volt alternator in your old car—a common upgrade—you can keep the stock wiring and the radio, but you'll have to change all your bulbs. It's perfectly fine to stick with the 6-volt system, but many like the brighter lights and increased starting power from the higher voltage. I think that upgrading to 12 volts is better than simply installing an 8-volt battery and leaving the 6-volt stuff in place because, eventually, you will burn out your bulbs.

The funny thing is that restomodding is not new, it's just that now there's a catchy name for the technique. I own a 1914 Premier—a big, brass-era car built in Indianapolis, with a huge T-head six-cylinder dual-plug engine. This car was upgraded in the late '40s, long before the term restomodding was ever uttered. The previous owner removed the coil and the magneto—it had redundant ignition systems—and installed a 12-cylinder ignition from a Pierce-Arrow. That's a really early example of restomodding. I get into this Premier, turn the key, and it fires; I don't have to start on the battery, then switch over to the magneto.

The brakes are a key safety issue and so are seatbelts. I install them in all my old cars, even if that feature wasn't originally available.

But no matter how much you upgrade an antique car, it is never going to be as safe as a modern vehicle. I hear dads say, "My kid wants a 1965 Mustang, which sounds like a perfect teenager car to me." That's not smart. Today, thanks to stiffer bodies that are designed to crush on impact and absorb energy, good seatbelts and airbags, drivers and passengers walk away from accidents that would have been lethal back when we were kids. That kid will be a lot safer in a later model Mustang or even a Ford Fiesta.

Some purists object to changing or modifying these old cars. I look at it this way: If it makes the car better, safer, more reliable and faster—and you can change it back to stock whenever you want—why not do it? **PM**

WHY TAKE A GAMBLE ON A PRICEY NEW GADGET? TO PLAY A ROLE IN TECHNOLOGY'S EVOLUTION.

Early-Adopter Manifesto

> BY GLENN HARLAN REYNOLDS
> ILLUSTRATION BY LEIF PARSONS

WHEN IT COMES TO HYBRID CARS, THERE'S BEEN a lot of push-back lately. But I'm an early adopter with more than five years of hybrid driving behind me, and I think it's been worth it—even though my investment probably hasn't paid for itself yet.

Skepticism about hybrids and electric cars seems to rise and fall in reverse step with gasoline prices—gas is pretty inexpensive right now, and the sneering level is high. For instance, car blogger the Auto Prophet (an automotive engineer) pointed out recently that to gain back the nearly $10,000 price premium on a new Chevrolet Volt, you'd have to drive the car for 9.3 years.

Well, never argue math with an engineer. But is math the answer here? Buried in the debate over hybrid economics are a couple of assumptions. One is that gas will stay cheap. Another is that the only reason to drive a hybrid is to save money on gas. I'm not so sure that either is true.

When I bought my 2006 Toyota Highlander Hybrid, I paid about $5000 more than I would have for a conventional Highlander. I've put just about 100,000 trouble-free miles on it since. Though I've gotten as much as 43 mpg when back-road hypermiling on my 10-mile drive to work, my overall mileage is around 28 mpg. That puts me about 6 mpg ahead of the nonhybrid Highlander for a fuel savings of 973 gallons so far—about $2900 at three dollars a gallon. So I'm still two grand in the hole. That makes me an idiot, right?

Well, possibly. Had gas prices climbed to European levels, I'd be way ahead—that could have happened. But I didn't buy the hybrid just to save money. I bought it because it was cool. The electric motors are almost noiseless, and they have more torque at low rpms, making my SUV quicker than a nonhybrid Highlander. Many drivers spend $5000 on options other than a hybrid powertrain—leather seats, a bigger engine, a great sound system—and none of those extras pay for themselves either.

It's a matter of what you value. In the early days of automobiles, bystanders often shouted "get a horse!" at motorists who were having mechanical problems. And, yes, horses were probably cheaper and more reliable. But that missed the point.

People who bought cars in 1900 wanted to be part of the future, and maybe even help it along. I'm a serial early adopter, and that's part of my thinking. My first computer—a Kaypro CP/M—wasn't cheaper than paying someone to type my college papers, but I was happy to own it.

Being an early adopter isn't just about being first; it's about being an active participant in technological progress. Those early purchases help jump-start manufacturing. And feedback from early adopters helps engineers get the bugs out before products go mainstream. It's been that way for radios, TVs, computers and pretty much every other piece of technology. Without early adopters, we'd wait longer—perhaps much longer—for new technologies to arrive.

There are personal advantages, too. When you jump in early, you get the fun of the new. A hybrid car, like one with a Hemi engine, is something to talk about. And it says something about who you are.

I plan to pass my Highlander Hybrid on to my daughter when she starts driving next year. Then I'll look for a new car. Maybe it will be a Volt, or a pure electric, like the Nissan Leaf. No doubt I'll be paying more and, unless fuel prices skyrocket over the next several years—as they didn't over the past several—I won't earn it back in fuel savings. But there will be other rewards, including the sense that I'm part of a new wave of technology that will benefit others down the line.

You can thank me later. **PM**

Limited Availability

Less Than ~~400~~ 290 Ounces of Tanzanite Remain in This Special Purchase.

2 carats of Genuine Tanzanite

Save $700!

African Gem Cutter Makes $2,689,000 Mistake...Will You?

This story breaks my heart every time. Allegedly, just two years after the discovery of tanzanite in 1967, a Maasai tribesman knocked on the door of a gem cutter's office in Nairobi. The Maasai had brought along an enormous chunk of tanzanite and he was looking to sell. His asking price? Fifty dollars. But the gem cutter was suspicious and assumed that a stone so large could only be glass. The cutter told the tribesman, no thanks, and sent him on his way. Huge mistake. It turns out that the gem was genuine and would have easily dwarfed the world's largest cut tanzanite at the time. Based on common pricing, that "chunk" could have been worth close to $3,000,000!

The tanzanite gem cutter missed his chance to hit the jeweler's jackpot...and make history. Would you have made the same mistake then? Will you make it today?

In the decades since its discovery, tanzanite has become one of the world's most coveted gemstones. Found in only one remote place on Earth (in Tanzania's Merelani Hills, in the shadow of Mount Kilimanjaro), the precious purple stone is 1,000 times rarer than diamonds. Luxury retailers have been quick to sound the alarm, warning that supplies of tanzanite will not last forever. And in this case, they're right. Once the last purple gem is pulled from the Earth, that's it. No more tanzanite. Most believe that we only have a few years supply left, which is why it's so amazing for us to offer this incredible price break. Some retailers along Fifth Avenue are more than happy to charge you outrageous prices for this rarity. Not Stauer. Staying true to our contrarian nature, we've decided to ***lower the price of one of the world's rarest and most popular gemstones.***

Our 2-Carat ***Sunburst Tanzanite Ring*** features marquise-cut gems set dramatically in gorgeous sterling silver. Each facet sparkles with the distinct violet-blue hue of the precious stones. Behind the shine you'll find that the exquisite silverwork of the setting calls to mind the detailed treasures being produced by Europe's finest jewelers. This is a ring designed to impress and it does not disappoint.

Now is the point where opportunity knocks. If you open that door today, you can own this spectacular ring for less than $100. If you wait? We can't say for sure.

Your satisfaction is completely guaranteed. For our client-friendly approach, Stauer has earned a rare **A+ rating from the Better Business Bureau**, a rating we wish to keep. So, of course, your satisfaction is 100% guaranteed. If you are not completely aglow with the ***Sunburst Tanzanite Ring***, send it back within 30 days for a prompt and courteous refund. But, please don't wait, our supply is dropping rapidly.

JEWELRY SPECS:

– 2 ctw genuine tanzanite – .925 sterling silver setting – Ring sizes 5–10

Sunburst Genuine Tanzanite Ring (2 ctw)—~~$795~~

Now **$95** +S&P *Save $700*

Call now to take advantage of this limited offer.

1-888 201-7112

Promotional Code TZR208-01
Please mention this code when you call.

ACCREDITED BUSINESS **Stauer has a Better Business Bureau Rating of A+**

Stauer 14101 Southcross Drive W., Dept. TZR208-01
Burnsville, Minnesota 55337

stauer.com

Smart Luxuries—Surprising Prices

1 *FLYWHEEL ENERGY STORAGE*

If we are going to retool our electric grid to incorporate more renewable energy sources, we need to find better ways of storing energy. One solution that has been talked about for decades is the use of flywheels: large, heavy wheels that store energy by spinning rapidly and release it through a generator that converts it back into electricity. The upshot: A utility can swiftly ramp up supply or taper it off to meet demand. After years of false starts, the first large-scale flywheel plant is set to open in 2011. Beacon Power's 20-Mw plant in Stephentown, New York, features 200 flywheels, each with a magnetically levitated rotor that spins at up to 16,000 rpm.

10 Tech Concepts You Need to Know for 2011

> BY ALEX HUTCHINSON

2 *WHITE-SPACE WIRELESS*

The electromagnetic spectrum is a crowded space, what with a world full of wireless signals bumping up against each other. And the sliver of spectrum left open for unlicensed use (meaning it can be used by any gadget, including Wi-Fi routers and cordless phones) is tiny. That's why technology companies are celebrating one side effect of the 2009 switch from analog to digital TV—the FCC ruled last September that the spectrum space once used by TV broadcasters will now be unlicensed. Even better, these so-called white-space wireless bands use short wavelengths that make them better than a typical Wi-Fi signal at traveling long distances and passing through obstacles such as walls and trees. Microsoft's corporate campus already has a wireless network using the technology, and Google is working with white-space equipment maker Spectrum Bridge on a pilot project at a hospital in Ohio, as well as a "smart grid" system for wirelessly managing electricity consumption in some California communities.

PHOTOGRAPH BY SPENCER LOWELL

THE GOODS

GREAT PRODUCTS AND PROMOTIONAL OFFERS FROM PM ADVERTISERS

INTRODUCING FRIENDLIER INSULATION

SAFETOUCH™ Fiberglass-Free Insulation, a product from Dow Building Solutions, is environmentally-friendly and incorporates technological developments to promote an indoor air climate that is comfortable, healthy and energy efficient. Free of itchy fiberglass, SAFETOUCH™ Insulation is manufactured from polyester fibers a percentage of which are derived from post-industrial recycled materials, making it safe-to-touch and easy to install.

For more information about SAFETOUCH visit **www.dowsafetouch.com**

WHAT WILL YOU DISCOVER WITH AN RV?

Go away for a long weekend or weeks on end. Throw a tailgate party. Revel in creature comforts among your fellow creatures. Starting at just $4,000, a new RV can help you do just about anything, just about anywhere. With our complimentary video, you'll ride along with five real families on their RV adventures. GoRVing.com

Go to **GoRVing.com**. Go Affordably. Go RVing.

THE SAMSUNG NX100

Featuring the iFunction lens, the **Samsung NX100** revolutionizes the way you take pictures. Push the iFunction button on the lens to change settings instantly while previewing them in real time on the brilliant AMOLED screen. It's a compact, interchangeable lens camera system that will transform camera enthusiasts into experts.

Visit **www.samsung.com** for more information.

SAMSUNG PC MEMORY

Samsung DDR3 is the ultimate memory solution for your computer. By applying industry-leading 40nm technology, Samsung DDR3 uses less power and is only two-thirds the size of conventional memory modules.

Whether it's a top-priority presentation or the highest level on your favorite game, now you can be equipped for maximum performance. Instantly. Efficiently.

Visit **www.samsung.com** for more information.

WIN TRON T1

ULTIMATE EXPERIENCE

HEADPHONES FROM MONSTER

EXCLUSIVE SWEEPSTAKES FOR PM READERS

Enter to win the TRON: Legacy T1 Headphones from Monster at www.poptron.com. Featuring sound isolation, studio-quality sound and TRON lighting effects in a single headphone design, these headphones give you the ultimate TRON: Legacy experience. Designed by Disney and engineered by Monster. Enter to win today!

Disney TRON LEGACY

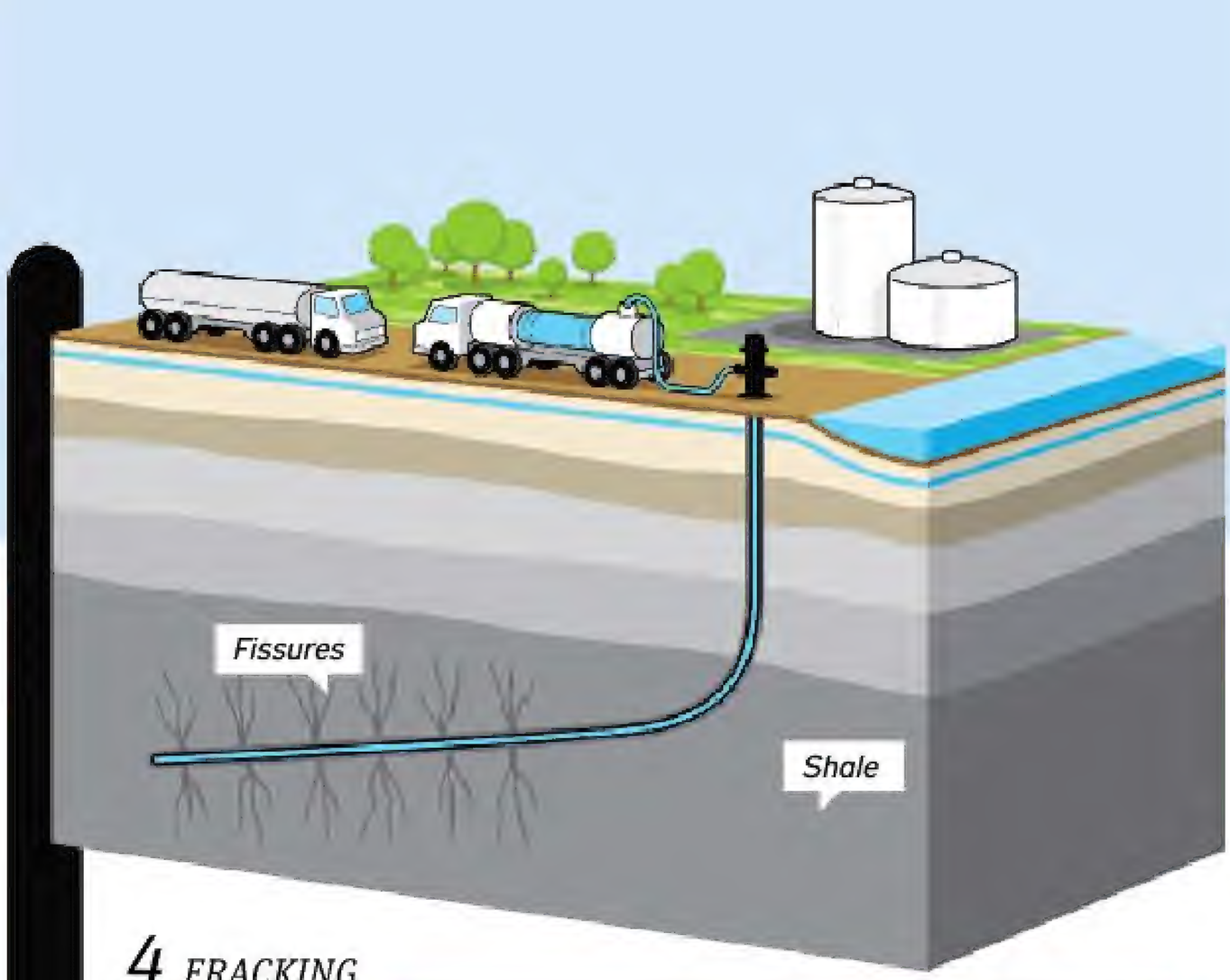
IN THEATERS IN 3D
12.17.10

Sweepstakes rules: No purchase necessary to enter or win. THE TRON: LEGACY T1 HEADPHONES SWEEPSTAKES, sponsored by Hearst Communications, Inc. begins December 10, 2010, at 12:01 AM (EST) and ends December 31, 2010, at 11:59 PM (EST). Odds of winning will depend upon the total number of eligible entries received. Open to legal residents of the 50 United States, D.C., and Puerto Rico who have reached the age of majority in their state or territory of residence at the time of entry. Void where prohibited by law. Sweepstakes subject to complete official rules available at www.poptron.com.

3 OPTOGENETICS

Until now, researchers looking to stimulate specific neurons had to rely on bursts of electricity—an imprecise and difficult-to-control technique. That's why the new field of optogenetics is so exciting. By combining fiberoptics and designer viruses, researchers can now stimulate neurons with a high degree of precision. This could allow, for example, the development of implants that can take over the functions of a brain region that might have been damaged by a wound or stroke. First, the brain is injected with a virus that is engineered to activate specific neurons when light hits them. A fiber-optic cable combined with an electrode then sends light into the brain, turning the neurons on and off, on command. Initial experiments used rodents, but researchers have now applied the technique to monkeys, and DARPA recently announced a project aimed at using optogenetics to help injured veterans.

Stanford University researchers Viviana Gradinaru, John Carnett, Murtaza Mogri and Karl Deisseroth use optogenetics to activate a rat's neurons.



4 FRACKING

Thanks to hydraulic fracturing—or fracking, as it's often called—America's shale fields are now capable of yielding massive quantities of previously inaccessible natural gas. Last year alone, estimates of unproved shale gas reserves jumped by 30 percent. Here's how it works: Sand, water and lubricating chemicals are mixed in a slurry blender, then injected into a well at pressures high enough to make cracks form in the surrounding rock, releasing the gas or oil trapped within its pores. Although the method has been used for decades, its use in horizontal shale wells is new—and attracting new controversy. Opponents cite the technique's environmental impact (drinking-water contamination is a particular concern), and studies suggest it may cause minor earthquakes. Energy companies and environmental groups are gearing up for a fight in the coming year.

5 MEDICAL ISOTOPE SHORTAGES

Radioactive isotopes are used in more than 50,000 medical procedures in the U.S. every day, from bone scans to cancer treatment. But America was left scrambling when the Canadian and Dutch reactors that supply most of the country's medical isotopes unexpectedly shut down for extended periods in 2009 and 2010. Both reactors are now online again, but shortages will likely return—the reactors are a half-century old and may not last much longer. And then there are the security problems associated with exporting weapons-grade uranium to other countries—even friendly ones like Canada—for processing. A bill aimed at promoting domestic isotope production is now making its way through Congress, and the Department of Energy has kicked in millions of dollars to develop new ways to produce isotopes.

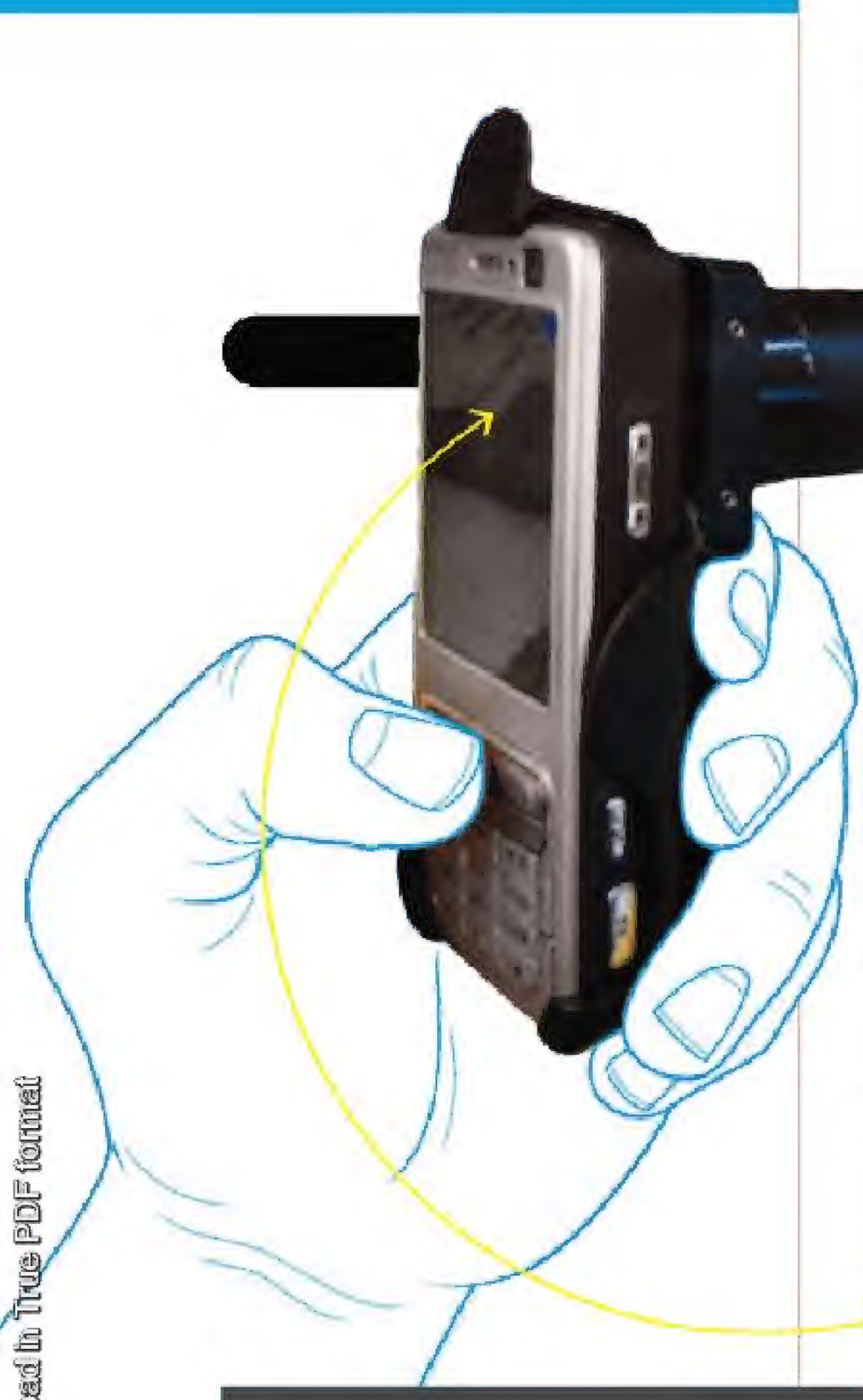
6 COMPLEX-EVENT PROCESSING

Corporations and governments routinely comb through enormous databases of information and images (such as those pulled from surveillance cameras) in search of patterns. But in today's data-rich world, an unfavorable signal-to-noise ratio can make it time-consuming and expensive to find anything relevant. A new generation of software is shifting the focus from "data" (a record of what's happened) to "events" (what's happening right now). Companies like StreamBase Systems and Tibco offer complex-event processing systems that analyze enormous flows of data in real time using new database and pattern-recognition approaches. This allows them to make instant decisions about whether to make a stock trade, initiate surveillance on a potential terrorist or halt a suspicious credit-card transaction. As the technology matures, we can expect these capabilities to trickle down to consumer devices. This would allow, for example, a GPS-enabled cellphone to sift through a constant stream of location-aware offers and alert users only to ones they would actually be interested in—such as deals on coffee along their morning commute route during the hours when they make the trek.

ILLUSTRATIONS BY **GLENN JONES**

7 MECHANOPHORES

America's infrastructure needs renewal, but we can't just rebuild everything at once: We need effective ways to figure out which structures are closest to failure. One approach is to integrate tiny wireless sensors into new construction. Another is to incorporate "mechanophores," a class of materials recently developed at the University of Illinois that change color when they are stressed. Mechanophores could give an engineer a quick visual indication of whether a bridge is at risk and where the trouble lies. The researchers are currently working to tune the reaction so that it can occur at any desired level of stress. They also hope to develop new mechanophores that undergo a self-healing response when they are damaged.



8 CELLPHONE DIAGNOSTICS

While trained medical care is a rare commodity in the developing world, cellphones are increasingly common. In fact, between 80 and 90 percent of the world's population now lives within range of a cell tower. That makes phones a powerful tool for bringing modern medicine to remote and poor areas. One approach pioneered by MIT spinoffs Sana Mobile and ClickDiagnotics is to have rural health workers transmit X-rays and other medical information via cellphone to far-off experts for diagnosis. Meanwhile, scientists at University of California, Berkeley, and a PM Breakthrough Award–winning researcher at UCLA have combined inexpensive microscope parts with off-the-shelf phones to produce devices that can record and instantly analyze microscopic images, detecting malaria parasites or tuberculosis-causing bacteria. The Berkeley-designed diagnostic tool, called CellScope, will be deployed in field trials in 2011.

9 HOMOMORPHIC ENCRYPTION

Researchers at IBM recently cracked a decades-old problem: how to encrypt data so that other people can sort and search it without actually revealing the contents. As cloud computing becomes more pervasive over the next year, this "homomorphic" encryption will allow companies to store sensitive data on remote servers, where it can be kept secret from the server's host, but still be easily accessed and searched. Users will also be able to enter search-engine queries and receive results without the search engine ever knowing or having a record of their query. The key breakthrough was a "double-blind" scheme that can check for encryption errors and fix them without revealing the data. Best of all, the researchers demonstrated that the technique can be implemented in just a few minutes on a standard PC, not just high-priced super-computers.

10 100 GBPS FIBEROPTICS

Thanks to data-hungry devices such as smartphones, the world now has an almost unquenchable thirst for bandwidth. A new generation of fiberoptic cables promises to meet the need, reaching a threshold of 100 gigabits per second—a significant jump from existing 10- and 40-gigabit-per-second cables, and enough to carry 15,000 HDTV channels simultaneously. Because the new cables encode two bits each in the polarization and phase of a light pulse, rather than a single bit in its intensity, they can pack four times as much data into the signal and reduce the impact of microscopic imperfections in the cables. Alcatel-Lucent has installed a 38-mile test link between two German universities and separately tested its 100 gigabit-per-second Ethernet equipment on Verizon's network in Dallas. The higher-speed cable is now available commercially and will likely carry some of the data you use in the coming year.

Battle Tank Ballet

> BY JOE PAPPALARDO
> PHOTOGRAPHS BY OLEG NIKISHIN

PM GETS A RARE RINGSIDE SEAT AT A FESTIVE RUSSIAN ARMS FAIR, WHERE THEATRICS, PATRIOTISM AND INTENSE SALES PITCHES REVEAL THE STRENGTHS AND INSECURITIES OF A FORMER SUPERPOWER REARMING.

Scenes from the fair (clockwise from top left): A T-90 tank takes a jump; families swarm a tank at the static displays; sweltering but appreciative Russians fill the viewing stands; barbarians clash with 12th-century Kievan Rus.

ZHUKOVSKY, RUSSIA—ANDREI MELANYIN, production director at the State Academic Bolshoi Theater, watches his performers rehearse from a director's chair, his legs neatly crossed. He's perched on top of a virtually empty grandstand, protected from the blazing summer sun by a beige tent. Everything about Melanyin is smooth, from his hand gestures to his answers during multilingual media interviews to the tanned crown of his head. A lesser professional would show nerves: After all, Prime Minister Vladimir Putin and an entourage of defense industry leaders and foreign dignitaries will arrive the next day to witness a portion of Melanyin's show, *Unbeatable and Legendary*. And in Russia, nobody's opinion means more than Putin's, who has become one part chief executive and three parts czar.

Melanyin evaluates the performers' pirouettes with a practiced eye, looking for mistakes; as the choreographer, he is intimately familiar with the routine. But the dancers in this performance weigh 46 tons more than a typical ballerina. The stars here are T-90 battle tanks that, along with dozens of other heavy military vehicles, are being showcased during a government-sponsored arms show held at this famed aviation test and design center just outside Moscow. On the parade field in front of the grandstand, a trio of the heavy tanks spin their turrets in unison, carefully rolling past one another in synchronized lurches. A pair of T-90s cross barrels as they roll forward. "They asked me to come in and do some-

Special Advertising Section

HOLIDAY GIFT GUIDE

INTERNATIONAL ARMS ///
BATTLE TANK BALLET

thing theatrical," Melanyin says of the event's government organizers. "They wanted something more than just a technical demonstration." Not only Putin will see this spectacular, set to debut before the VIPs on Thursday: Tens of thousands of Russian civilians are expected over the weekend.

This strangely festive arms show is a reflection of the ambitious transformation of the Russian military. In 2010, the Federal Service for Military and Technical Cooperation (FSMTC) combined several dry defense trade shows into a single event and turned part of it into a patriotic pep rally. The organizers needed something to get people's attention—hence the nexus of brutish tanks and graceful ballet.

After the T-90s finish practicing the synchronized dance, the rehearsal moves on to more conventional theatrics. The show covers Russian fights against classic foes, including 12th-century barbarians, Napoleonic troops and modern, masked insurgents from breakaway provinces. Melanyin's booming voice addresses a pair of actors dressed as imperial Russian cannoneers, who are struggling with a pint-size cannon, telling them to take their routine from the top. "I asked for 200 volunteers, but I got just 20," he explains later. "And I spent all my volunteers on the 12th century."

THE ENGINEERING TECHNOLOGIES Forum opens quietly. Guests file through the main gates, located near a boneyard where retired Russian warplanes are cannibalized for spare parts. The Soviet military was so vast, and fell apart so thoroughly, that fields of neglected equipment are known for their epic, horizon-to-horizon size. This one is comparably modest, but any aviation enthusiast would be content to spend the day examining the well-worn Tu-95 bombers, MiG-21 fighters and Mi-24 Hind helicopters.

The Soviet Union produced massive amounts of weapons, and after its 1991 dissolution, the Communist government sold as much as possible. Former Cold War allies remain customers of the Russian Federation. In 2010, the nation exported about $9.5 billion in arms, a billion dollars more than in 2009. The United States' arms sales dwarf Russia's—in 2010 alone, the Obama administration finalized a $6.6 billion deal with Taiwan and announced a $60 billion agreement with Saudi Arabia, the biggest arms sale in U.S. history.

RUSSIANS APPROACH THE TOOLS OF WARFARE IN AN UNABASHED, ADORING WAY.

Still, there is a robust market for Russian arms among nations looking for good deals with few strings attached. Representatives from dozens of countries attend the first, business-focused days of the forum, wandering the aisles inside converted hangars, chatting with spokesmen and booth bunnies. Iranian academics in slacks and long-sleeve shirts wander the exhibition, pausing to check out new antiaircraft-missile seekers, while United Arab Emirates delegates in dark suits examine obstacle-clearing vehicles parked outside. Putin himself squires Ali Abdullah Saleh, the president of Yemen, around the T-90s on display.

But selling weapons is only one part of Russia's newfound ambitions. Over the past decade, the government has consolidated most of the defense industry under federal control and set the nation's sights—and oil revenues—on rearmament. Putin's plan is to create a better-trained, more mobile force that can deftly fight guerrillas while countering Western influence in Eastern Europe. "The most important thing is that the [Putin regime] has a vision of what they want the military to be," says Dmitry Gorenburg, editor of *Russian Politics and Law*. "Since the Cold War ended, the government didn't have that."

THE WEEKEND IS RESERVED for the Russian people. American air shows may indulge in some family-friendly militarism, but Russians approach the tools of warfare in an unabashed, adoring way.

The FSMTC estimates that 50,000 attend the show. The plastic furniture, steady odor of grilled meat and overhead formations of kites evoke the feeling of a music festival. Young men take photos of their sweethearts posing languidly against armored personnel carriers. Dads photograph their kids hoisting rifles or straddling antiaircraft missiles.

Tens of millions of fathers and uncles of Russian teenagers served in the Soviet Army. More important, their grandfathers served in World War II. Veterans of that era are treated with a reverence that is unequaled in America. After all, Russia was fighting for its very existence in World War II; an estimated 20 million civilians and soldiers died, compared with 400,000 American dead. Americans don't visit memorials of war vets on their wedding day to give thanks, as Russian couples do.

The government is eager to stoke this patriotic heritage as the country rearms. The reason is conscription:

Despite recent efforts to wean its armed forces from the draft, the Russian military still relies on conscripts. However, it is easy to defer service for legitimate reasons, or by bribing a doctor for an exemption, sapping manpower. Patriotic displays are part of the government's solution: It's not a coincidence that kids under 14 get into the arms show for free.

Unbeatable and Legendary begins in the 12th century and skips like a fake gemstone across the surface of Russian history. The crowd watches politely, with tepid applause, as the Russians vanquish barbarians and the French with humble special effects like flaming clubs and one-fifth-scale cannons. The crowd perks up when paratroopers in blue berets perform feats of hand-to-hand combat. The strains of Ravel's *Bolero* give the display a surreal feel, the passionate, surging music an odd complement to violent hip tosses, brick-crunching punches and mock-fatal blows delivered by shovel-shaped entrenching tools.

Then a true icon appears: a T-34 medium tank, a workhorse from World War II. The sight provokes an immediate emotional reaction in the stands. "The one thing from the 20th century that Russian people can unqualifiedly call 'good' was that they won World War II," Gorenburg says. The reenactor in the turret is beaming, bathed in applause as if he were an actual Great Patriotic War veteran.

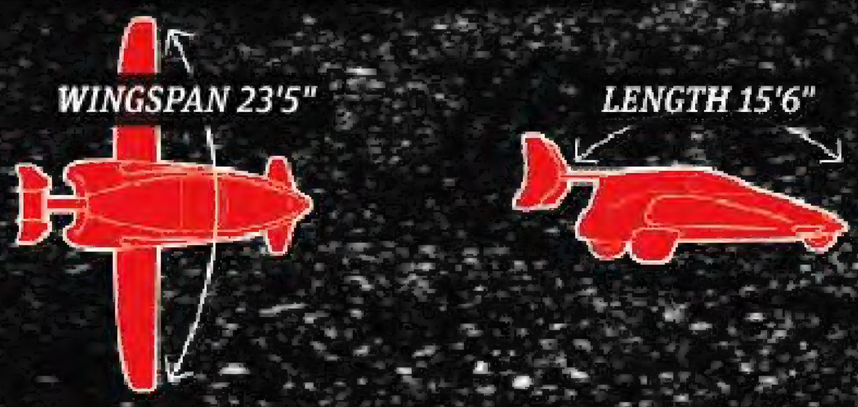
Heavy-metal music heralds the arrival of the modern tanks, starting with a T-80U kicking up a spray of gravel as it roars past the viewing stands. A pair of T-90s tear into the demonstration area like the top-of-the-food-chain predators they are. One by one, the T-90s roar toward a 4-foot ramp, building speed for the jump.

As a tank takes to the air, the rhythmic mechanical squeal of the treads goes silent, and there is a thump, felt in the feet and stomach from 30 yards away, when the 46-ton vehicle slams back to the ground. "It's as easy to operate as a car," one driver tells a Russian television crew. "The only difference is you steer with levers instead of a wheel."

The electric guitar cuts away and, as a martial pomp begins, the T-90s gather on a concrete slab at the center of the course. First, two tanks cross their gun barrels and ease forward together. A third main battle tank arrives, and the three pirouette—one of the few terms shared by tanks and ballet—in unison. The trio maneuver with unexpected precision. The synchronicity falters, but the tanks never touch—an impressive feat considering the vehicles' girth.

The standing-room-only crowd claps at the display. Melanyin does not confess to any of the jingoism in his latest, strangest ballet. "All I want," he says of the crowd's reception, "is to hear their applause." When the national anthem plays and the vehicles slide past in a rolling curtain call, it's easy for a foreigner in the stands to avoid a twinge of pride. But as the audience claps and sings along, it becomes hard not to feel left out. **PM**

Samson Motorworks has developed this tubular buggy to test the driving characteristics of what the company hopes will be a sleek flying motorcycle called the Switchblade. The superimposed illustration shows the final design .



TODAY'S ROAD PROTOTYPE	TOMORROW'S AIRCRAFT
SPEED Over 100 mph	150 mph (cruise)
MATERIAL Steel tube frame	Carbon composite with steel keel
POWER Suzuki Hayabusa motorcycle engine	Bifurcated-intake ducted fan

driving on air

The flying car—it's been a tantalizing but elusive dream since the early days of aviation. Now a new wave of entrepreneurs, NASA and the Pentagon are trying to reinvent personal flight and put an aircraft in every garage. But the engineering challenges remain as formidable as ever.

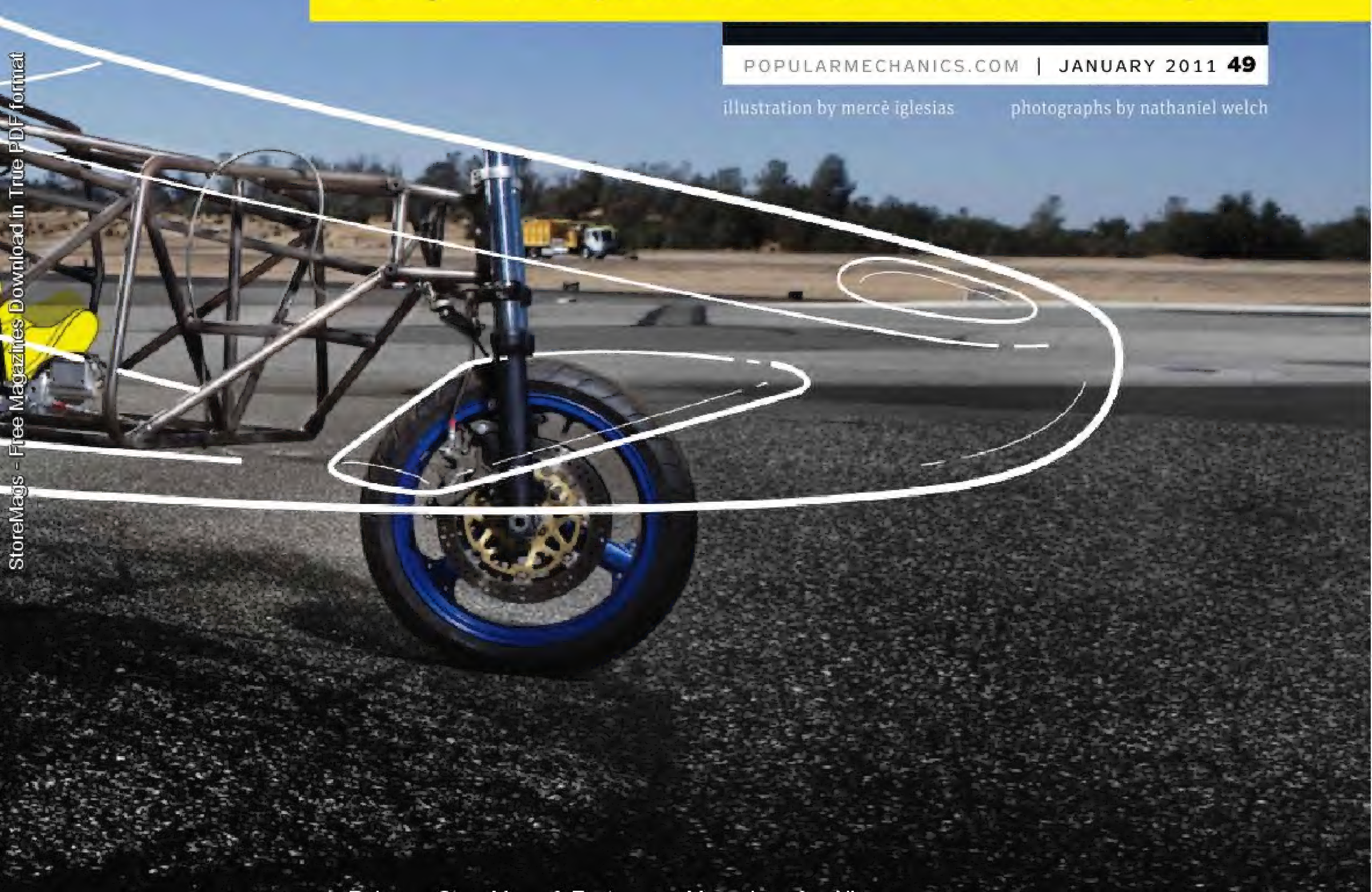
by sharon weinberger

Even at its best, the Golden West Airshow in Olivehurst, Calif., is not one of the country's premier aviation events. The annual weekend-long celebration of light sport and experimental aircraft usually attracts only a few thousand spectators to Yuba County Airport. This year's turnout is especially light. High winds have kept some performers away and are preventing small-plane pilots from flying in to the venue, but the show must go on.

The pilots and prop-heads in attendance crane their necks to watch pairs of Aerobatic Racing Challenge biplanes corkscrew through a sequence of complex aerial maneuvers. Other visitors wander the booths seeking memo-

illustration by mercè iglesias

photographs by nathaniel welch



rabilia, airplane sales pamphlets or overcooked hamburgers.

Away from the flight line, about 25 people are seated inside a hangar, only partly sheltered from the gusts blowing through the open door, to hear a speech titled "Move Over, Jetsons!" Sam Bousfield, founder and president of Samson Motorworks, picks up a handheld microphone and begins to tout his flying motorcycle, the Switchblade. "It's two vehicles in one, an airplane and a car," he says. "Go pick up groceries, drop off your grandma at the beauty salon, fly to San Francisco."

A 4-foot model of the aircraft sits on a folding table in front of Bousfield, its narrow nose inclined at a slight angle for maximum viewing impact. The race-car-sleek lines, tinted windows, curved rear aerofoil and bright red paint are designed to reel in investors and fire the imaginations of pilots.

Bousfield also uses the model as a prop to describe the craft: It's a two-seat, three-wheeled vehicle sheathed in a lightweight carbon-fiber shell. An owner would drive the Switchblade to anywhere a general aviation aircraft can take off, then swing out the wings and extend the telescoping tail to prepare for flight. When the Switchblade returned to the ground, the pilot would button down the flight-control surfaces inside clamshell doors underneath the chassis.

Samson Motorworks plans to sell the Switchblade as a $60,000 kit aircraft, meaning that owners must buy an engine and construct at least 51 percent of the finished product. The final price could reach $85,000, comparable to other kit aircraft. "Why would I spend my time and investors' money coming up with something as wild as this?" he asks the audience. "When I look at aviation, the only thing wrong with it is that it's not done enough."

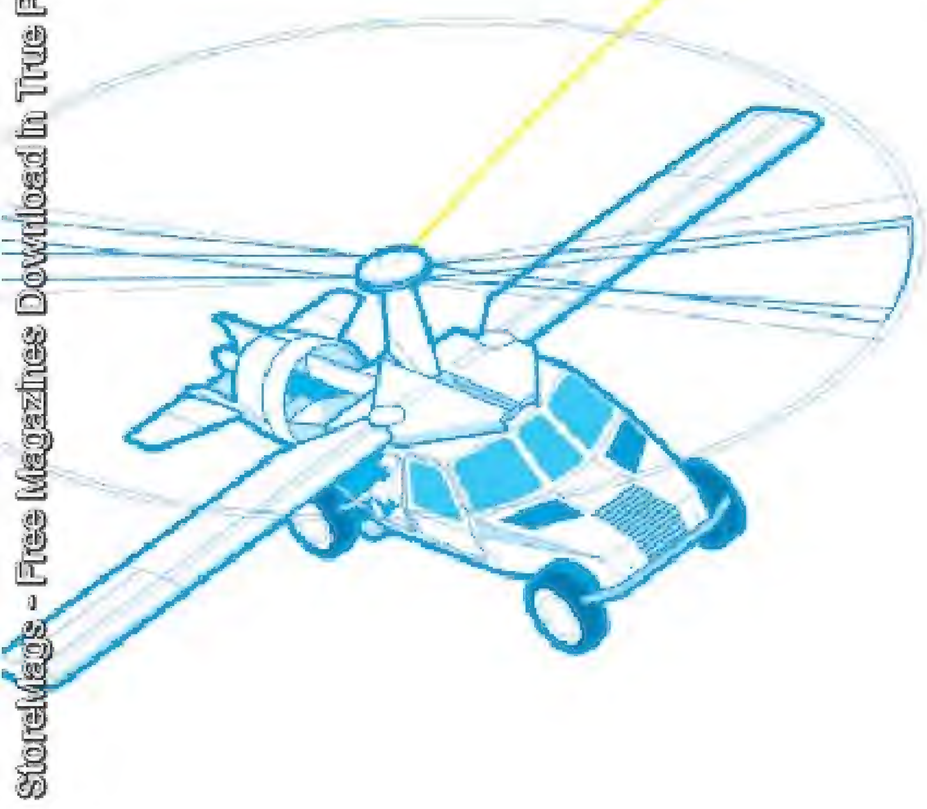
But as the Q&A session after the speech makes clear, the audience members have not been fantasizing about the *Jetsons, Blade Runner* or *The Fifth Element*. They have more pragmatic considerations on their minds.

"Does it have legal clearance for California roads?"

"Is the wing retraction mechanism manual, hydraulic or what?"

"Is it possible to put in a four-cylinder engine, like a Subaru's?"

Even though Bousfield fields each question with enthusiasm, no one puts down a $2000 deposit. If a rousing speech cannot convert pilots into customers, perhaps a demonstration of the hardware will do the trick.



But the flying-car prototype in Samson Motorworks' Booth A-27 bears little resemblance to the Ferrari-inspired model in the hangar. For one thing, it's missing certain design elements common to aircraft—like wings. The vehicle, a triangular lattice of bent steel tubes enclosing two seats and a rear-mounted engine, is more dune buggy than airplane. Bousfield and his employees stayed up until 2 am preparing this kluge of a skeleton for the first test of the Switchblade's drivetrain, suspension and steering.

Bousfield is not just the company's president, he is also its test driver. He climbs into the prototype.

"It's our inaugural flight," he announces to a dozen onlookers. "Well, not quite a flight."

He turns the ignition, the 1340-cc four-stroke four-cylinder engine roars, and the Switchblade scoots across the asphalt. When Bousfield reaches the end of a row of hangars, he slows and makes a sharp turn—the Switchblade's first. The metal cage handles the maneuver with ease. On the return leg, feeling more confident, he mashes the accelerator and the Switchblade speeds to 40 mph. Back at the booth, Bousfield is exhilarated that the prototype passed its first—and very public—test. But the onlookers just want to know about the turn radius, aileron control and takeoff and landing performance criteria.

In Yuba County, flying-car fantasies are a tough sell.

The air show demonstration may seem humble, but the Switchblade is far closer to reality than most flying-car concepts ever get. The history of roadable aircraft, as their proponents call them, is littered with frustrated ambitions. Glenn Curtiss's failed 1917 Autoplane, which was supposed to usher in an era of ubiquitous flying-car ownership, was the first of many disappointments. Over the decades, dozens of companies have drawn blueprints, built prototypes and solicited investor money, and ended up with almost nothing to show for their efforts.

Why have so many talented dreamers failed to make the flying car a reality? The answer: physics. Cars and airplanes operate in very different environments, so building a car that doubles as an airplane results in an inferior version of both. The challenges are so intractable that flying cars have become a cultural punch line, a metaphor for technological promises that never come true.

Despite all that, the dream is very much still alive. Over the past 10 years, scores of startup companies have proposed a new generation of dual-purpose vehicles. In 2010, the I-TEC Maverick, which is a dune-buggy-style vehicle with a pusher prop and parachute, was cleared for flight by the FAA and for the road by the state of Florida.

Other outfits have dodged fly–drive pitfalls by designing personal air vehicles that require neither roads nor run-

ILLUSTRATIONS BY DOGO

6 New Ways to Fly

Players on aviation's fringes are producing radical personal aircraft that go beyond the flying car.

Vehicle/Developer	Type	Description	Status
M400X Skycar / Moller International	Vertical takeoff and landing (VTOL) aircraft; prototype 	The Skycar points four ducted fans down to take off vertically; the fans swivel to provide thrust during flight.	Inventor Paul Moller has been developing the concept for nearly 50 years. To date, the M400X has only hovered on a tether.
Martin Jetpack / Martin Aircraft Company	Ultralight personal helicopter; commercial product 	A rider uses two gasoline-driven, 1.7-foot-diameter ducted rotors to fly up to 31.5 miles at an FAA-mandated maximum speed of 63 mph.	In 2010 Martin landed a $12 million outside investment to build 500 packs. They will be sold to governments and defense firms for $100,000 each.
CarterCopter / Carter Aviation Technologies	Autogyro rotorcraft; prototype 	Wings and a twin-boom tail help the helo fly at slow rotor speeds, but it can only hover for seconds. On June 17, 2005, it broke a record for slow-rotor flight but crashed later that day.	Carter engineers are building a larger prototype. The company, founded in 1994, is still seeking a partner to commercialize its manned and unmanned designs.
Maverick / I-TEC	Roadable, powered-parachute buggy; commercial product 	Florida-based I-TEC designed this $80,000 off-roader for missionaries in the Amazon. It stays aloft using a parachute and rear propeller.	PM gave I-TEC a Breakthrough Award in 2009. In late 2010 the Maverick became the second U.S. flying car to be declared street- and air-legal; the first was approved in 1956.
Milner AirCar / Milner Motors	Roadable aircraft; prototype 	This four-door car, about the size of a Honda Civic, has a foldable main wing in the rear of the vehicle and a canard in front.	Milner's designers have driven, but not flown, the AirCar. The company is seeking an aeronautical firm to conduct flight tests intended to validate the prototype's design.
Transformer TX / Defense Advanced Research Projects Agency	VTOL Humvee; government research project to create prototypes 	In 2010 the Pentagon selected companies to design two versions of a flying jeep. One design uses an exposed rotor and wings; the other, ducted fans.	The Pentagon gave Lockheed Martin and AAI, a unit of Textron Systems, $3 million each to build prototypes as part of a $54 million program.

Terrafugia Transition: It may not be sexy, but Terrafugia has some assets that other flying-car companies envy: substantial private investment, more than 85 preorders and a round of flight tests. In 2010, the Transition won an exemption from the FAA allowing it to be evaluated for certification as a light-sport aircraft, even though it was 110 pounds over the maximum weight. An owner could fly the aircraft with a light-sport pilot's license, which requires just 20 hours of training.

ways. Martin Jetpack has lined up funding to build a factory that will produce a backpack mounted with shrouded propellers. In addition to these private sector players, the Pentagon is funding a flying Humvee program; NASA is designing a one-person electric helicopter/small-aircraft hybrid for commuters.

This renewed interest has been spurred by changes in aviation, including the widespread use of lightweight carbon-composite materials, the advent of smarter flight control computers and new FAA regulations that reduce training requirements for pilots of small aircraft.

It seems like a hopeful time for the flying car. "The appeal is obvious," says R. John Hansman, director of the MIT-based International Center for Air Transportation. "There's always a market—if you can do it well." But the odds—and the physics—are still stacked against the enthusiasts.

Cars With Identity Crises

The Transition, the most advanced flying car in the United States, rolls down a runway, gathering speed at the start of its test flight. The pusher propeller at the back of the car buzzes loudly as the nose lifts and the car lurches into the gray skies over Plattsburgh, N.Y.

Once airborne, the Transition prototype looks like a bulky light-sport plane, with a bulbous fuselage, a 26-foot 6-inch wingspan, a slender twin tail and a wide front bumper that doubles as a canard. The flight is brief, about a minute. The Transition does not rise higher than 300 feet and never veers from the safety of the 2-mile runway, which was designed to accommodate massive B-52 bombers. The test pilot uses every bit of the long stretch of asphalt to set down.

Terrafugia quietly conducted this milestone flight in March 2009, away from the eyes of the public and press. (The company has released videos of only three of Transition's 28 test flights.) If Samson Motorworks is trying to be the showy cardinal of the flying-car world, then Terrafugia is content to be the secretive thrush.

Formed by five MIT graduate students in 2006, the company is built on solid engineering and tech-business roots. Carl Dietrich, who spearheaded Terrafugia's creation while he was still working on his Ph.D. in aeronautics and astronautics, wants to build a product for pilots who don't want to pay for hangar space. It's a practical business model applied to an infamously impractical idea. "People tend to have popular-culture visions of flying cars," Dietrich says. "The reality does not

Road-Worthy vs Air-Worthy

Made to Drive		Made to Fly
		
Engines are designed to withstand varying rpm, since drivers constantly speed up and slow down.	ENGINE	When flying, airplane engines run at a near-constant rpm that is about half a car's maximum.
Car wheels are at the perimeter of the vehicle, away from the center of gravity, to provide stability.	WHEELS	Landing gear is near the center of gravity so a pilot can easily raise the airplane's nose for takeoff.
Features like spoilers disrupt airflow that generates lift to ensure a car grips the road as it accelerates.	AIRFOILS	Airplanes are shaped to generate more lift the faster they go; wings bend airflow to maximize the effect.

The idea of an aircraft in every garage has enticed the American public for decades. From left: In 1951, the magazine dubbed Stanley Hiller's mini rotorcraft "Your Helicopter Coupe." By 1957, his "aerial sedan" incorporated ducted fans. In 1994, Ken Wernicke's Aircar graced the cover. None of these craft, or any like them, have ever appeared in PM's New Cars section.

match that set of expectations. However, the reality is Transition offers a freedom that does not exist in the aviation market."

The Transition is a car that has been adapted for flight, and that simple fact brings some serious limitations to its performance as an aircraft.

During takeoff, for example, an airplane's wings must be at a certain angle, at a certain speed, to generate enough lift for flight. When a pilot reaches takeoff speed, he pivots the airplane's nose over its center of gravity, a maneuver called rotation.

Most engineers position the main landing gear close to the airplane's center of gravity for easier rotation, which allows for takeoffs and landings at relatively slow speeds on short runways. But Transition's wheels—like those on most flying cars—are at the perimeter of the chassis. And for good reason: If a car's wheels were at its center of gravity, a pothole or speed bump could flip the vehicle. But, Dietrich admits, "it makes for some different takeoff dynamics." In other words, Transition owners will need to find long runways.

"Look at the video," says aeronautical engineer Austin Meyer of the Transition's test flights. "The pilot has the elevator fully deflected and he can still barely raise the nose." Meyer is the creator of X-Plane, the leading flight simulator for personal computers. Other simulators use data from test flights to plug into simulations; X-Plane can predict how an aircraft will handle in flight while it's still being designed.

The simulation models the aerodynamic forces on aircraft parts: A wing is not judged as a single component; it is split into dozens of sections, each of which is evaluated separately. When Meyer flew the Transition in his simulation, he found that its twin vertical stabilizers, canards and external wheels created enough drag to degrade the flight performance.

Even supporters acknowledge the vehicle's limitations. "The Terrafugia guys have done a good job," says MIT's Hansman, who advised the company. But no matter what, "it's a compromised car and a compromised airplane."

The Switchblade tries to avoid this conundrum by placing its three wheels in a configuration similar to an airplane's. The large rear wheels remain at the edge of the vehicle, like a car, but

ILLUSTRATIONS BY DOGO

Bousfield promises a quick takeoff since the craft only needs to lift its nose 4 degrees to fly.

But X-Plane's Meyer says the Switchblade faces other aerodynamic problems. When he tested the components, using the company's specs, he found the aircraft's small stabilizers—located behind the rear wheels for a convenient automobile layout—were not effective at steadying the airplane during level flight. "It could be flyable," Meyer says. "But the flying characteristics would be poor."

Sam Bousfield's Switchblade flying motorcycle currently exists only in artists' renderings and as a buggy used for road tests. In recent trials, Bousfield says the road prototype broke 100 mph.

The difficulties of engineering a flying car are also found under the hood. In flight mode, the Switchblade routes power from its motorcycle engine to the blades of a ducted fan, whereas the Transition uses its plane engine to power a pusher propeller. In the case of the Switchblade, the engine's duty cycle will be far different in the air than it will be on the ground.

The driver of a land-based vehicle frequently accelerates, stops and turns. The engine's revolutions per minute (1000 to 6000 rpm) and power curve aren't broad enough to accommodate this speed range, which is why a car engine is fitted with a transmission. A small airplane's engine runs at a lower but relatively constant 2000 to 3000 rpm and, unlike a car engine, generates nearly maximum torque at full load for most of its operation.

Some recreational pilots use car engines for aircraft, but adapting them is complicated. The pilots need to figure out ways to dump heat, since the thin air and high load make an engine in flight work harder than one in use on the ground. To increase reliability and to prevent overspinning of the prop, the repurposed car engines are configured to run slower, and the bearing clearances are enlarged, which increases oil flow and helps cool the engine.

Due to the differences in performance and operating temperatures, powertrains adapted for both flight and road work tend to be heavier, more complex, less reliable and more expensive than single-use engines. Engineers are aware of the problems that tradeoffs can cause. "They've got reasons for their decisions," Meyer says. "But the reasons usually come down to basic laws of physics that prohibit cars from ever flying efficiently."

Uncle Sam's Puffin

Known as a loner, the puffin is an awkward-looking bird with wings that seem too small for its rotund body. It's appropriate, then, that engineers at NASA adopted the moniker for their

Flight of the Puffin

How NASA's single-rider concept craft will avoid traffic-clogged commutes.

1 • ***READY FOR LIFTOFF:*** The rider steps into a pressurized cabin and straps in, standing up. He starts an almost totally automated flight by entering a destination into the flight-control computer.

2 • ***RISE UP:*** The Puffin is classified as a "tail sitter." As the 7.5-foot props spin, the craft ascends and the legs fold together to form a tail.

3 • ***TIP OVER:*** Instead of rotating the nacelles, the Puffin pitches forward to fly like an airplane.

4 • ***FLY FACEDOWN:*** The Puffin cruises at 150 mph and soars up to 30,000 feet. Lithium-phosphate batteries power flights of up to 50 miles—long enough to complete the average U.S. commute.

bizarre one-person aircraft that takes off from an upright position.

Mark Moore, an aerospace engineer at NASA Langley who designed the Puffin, is not interested in trying to meld airplanes and automobiles. Instead, he envisions a radical personal aircraft with only one mission—to deliver a commuter to his office. On a budget of less than $1 million, Moore designed the Puffin to avoid gridlock.

Here's how the Puffin could redefine a typical commute: A rider walks to his backyard, steps into the cockpit, enters his destination into the flight-control computer and takes off. Two electric engines, powered by 100 pounds of lithium-phosphate batteries, are so quiet that the rest of his family doesn't know he's leaving for work.

The commuter steers the Puffin with a two-axis joystick to indicate direction and speed, and the flight-control computer translates the input into movement of the Puffin's control surfaces. Always on some level of autopilot, the craft would not obey dangerous commands.

At a predesignated altitude, automatic controls take over. Instead of rotating its engine nacelles, like a traditional tilt-rotor aircraft, the Puffin tips its entire body (and its passenger) over onto its belly for forward motion through a flight corridor—a sort of bicycle lane in the sky.

In Moore's world, the nation's airspace is open to unmanned aerial vehicles. In reality, the FAA has been reluctant to allow UAVs to share the sky with airliners, sport aircraft and helicopters. The Pentagon is leading the effort to draft the rules and define the technical standards that will open the nation's airspace.

Pressure is mounting to do so as federal and local agencies develop plans for using drones to monitor weather, provide tactical reconnaissance for police or conduct environmental studies. So commuting in a Puffin would be like hitching a ride on a UAV studded with collision-avoidance sensors and wired for direct communication with other aircraft and sensors on ground infrastructure.

Flying in a prone position might be unacceptable to most commuters. But there's one thing Moore does not have to worry about that consumes flying-car companies: marketability. The government's role, Moore believes, is to come up with the innovations and regulations needed to finally build a flexible point-to-point transportation system. What companies sell, and what products customers will actually buy, is another matter. "Let the private market figure it out," says Moore. "It always does." **PM**

ILLUSTRATION BY **ESTUDIO DIGITAL**

INTRODUCING THE HIGH-TECH, CUTTING-EDGE, CARBON-NEUTRAL, ALTERNATIVE FUEL OF THE FUTURE:

wood.

By Logan Ward
Photographs by Christopher LaMarca

EE RICHARDS LIVES WITH HIS WIFE IN a 1957 brick rancher in a neighborhood of cookie-cutter homes in Charlottesville, Va., where he works as the city's commissioner of revenue. In the past decade, he decided to become a more self-sufficient consumer of energy. He commutes to work on foot and by bus. He powers his home with 18 solar panels bolted to his roof and sells the excess electricity back to the grid. He heats his water with a solar-thermal system. And he heats his home in winter with biomass—in this case, firewood—using three small but highly efficient Jøtul wood stoves in the living room, sunroom and basement. He spends $1200 a year on wood—five truckloads, split and delivered—and gets up at four o'clock each winter morning to stoke dying embers so his wife will be warm when she wakes. When he returns from work, he throws on a few more logs, and the stoves whoosh to life. His gas-fired central heating system remains installed as backup. Yet he saves over $1000 per year on fuel costs, and his utility bills rarely total more than $100 a month.

A century ago, and for about 400,000 years before that, most people burned wood to stay warm. Then the arrival of oil- and gas-fired central boilers and furnaces liberated them from the toil, mess and smoke. Today, fluctuating prices, a desire for independence and a new generation of clean, efficient stoves have attracted homeowners like Richards to a flourishing back-to-basics home-heating movement. Annual shipments of pellet stoves, which burn biomass in the form of compressed sawdust from lumber mills or managed forests, jumped from 18,360 to 141,211 units between 1999 and 2008, a 650 percent increase. Large-scale installations include Vermont's Bennington College, which uses a wood-chip-fueled biomass boiler to heat 85 percent of its campus.

Consumer incentives are also helping drive the shift to biomass heat. A $1500 federal tax credit for high-efficiency wood and pellet stoves—part of the American Recovery and Reinvestment Act of 2009—expires at the end of 2010. But at least two pending bills propose to expand and increase the credit up to $6000 to subsidize the purchase of stoves, biomass boilers and furnaces. Congress is pushing the passage of its Homestar legislation, a $6 billion incentive program to encourage residential energy efficiency, which could spur adoption of wood stoves and other biomass heat sources.

The impact of a widespread switch to biomass would be huge. Heating accounts for about half of U.S. residential energy consumption. The most popular fuel, natural gas, heats 50 percent of U.S. homes. About a third of the country heats homes with electricity. John Ackerly, president of the Maryland-based Alliance for Green Heat, says, "Electricity is too inefficient and too expensive to make and waste on heat." The same goes for the 5 billion gallons of oil and 15 billion gallons of propane that are used annually to heat 20 percent of American homes. If all oil customers switched to biomass, the savings could amount to 120 million barrels—1.68 percent of the 7.14 billion total barrels of oil consumed per year. Pellet stove inventor Jerry Whitfield's objective is clear: "We're trying to displace oil as a home heating source," he says.

Improved technology is also helping drive the biomass revival. New stoves designed to handle clean-burning wood-waste pellets mean greater efficiency and lower emissions. In the past 25 years, the North American wood-pellet industry has grown from a few small outfits to well over 100 companies that produce more than 1.8 million tons of pellets per year. New systems to efficiently transport and store

"WE'RE TRYING TO MAKE WOOD HEAT A FIRST-TIER RENEWABLE," SAYS THE ALLIANCE FOR GREEN HEAT'S JOHN ACKERLY, BELOW.

PHOTOGRAPH BY MELISSA GOLDEN

How to Heat a House

The average 2400-square-foot house burns around 100 million Btu of fuel per year. The prices below for natural gas, fuel oil and propane are based on 100,000-Btu furnaces and boilers with installation costs of $1000 to $2000. Note that electricity seems cheap only on a kwh basis, not in total.

HEAT TYPE	INSTALLED COST	EFFICIENCY	FUEL UNIT	FUEL COST (PER UNIT)	HEAT PER UNIT (BTU)	FUEL COST (PER MM BTU)	ANNUAL COST (FUEL/MAINT.)
FOSSIL							
NATURAL GAS	$3000-$5550	80-98%	THERM	$1.05	100,000	$13.52	$1352
FUEL OIL	$2300-$3800	78-87%	GALLON	$2.65	138,900	$24.46	$2446
ELECTRIC HEAT PUMP	$5500 (24,000-BTU)	92-98%	KW/HOUR	$0.111	3412	$33.21	$3321
PROPANE	$2750-$5650	78-98%	GALLON	$2.11	91,333	$29.58	$2958
BIOMASS							
WOOD STOVE	$3000-$4200	70%	CORD	$200	22,000,000	$12.99	$1299
PELLET STOVE	$3500-$4000	78-85%	TON	$250	16,500,000	$18.94	$1959
MASONRY HEATER	$13,000-$25,000	80%	CORD	$200	22,000,000	$11.36	$1136

pellets make the fuel economically viable in more locations than cordwood. New England Wood Pellet pioneered a bulk delivery system modeled on agriculture and the heating-oil industry. "Pellet fuel flows like grain, so you can use conventional storage technology and a flexible auger tube to move the fuel around," Charles Niebling, general manager of New England Wood Pellet, says. "It lends itself to automation." Companies like WoodPellets.com, started in 2005 by two engineers with graduate degrees from MIT's Sloan School of Management, are hoping to increase fuel distribution efficiencies by creating a system modeled on European infrastructure, complete with pneumatic pressurized-air trucks and satellite storage depots.

These advances will reduce the price. "Virtually everyone who owns solar panels has either green motivation or a fascination with new technology," says Dan Freihofer, vice president of operations at WoodPellets.com. "But the average pellet-stove owner buys one of

these things because he's sick of writing $600 checks to the oil man. He puts one in to save money—tomorrow."

Central heating powered by electricity or fossil fuels has relegated biomass-burning stoves to a supporting role in the U.S. As in Richards's case, they are often retrofitted supplements to existing systems. In some European countries, biomass is the primary heat source, fueling central boilers for residences, apartment buildings and even whole towns.

In the U.S., the biggest hurdle that New England Wood Pellet CEO Steve Walker sees is the high cost of the equipment, particularly central boilers that could bring biomass into the mainstream. "It's the classic Catch-22 of any new technology," he says. "You need to scale up manufacturing in order to produce something for a reasonable cost, but you need a market before you can do that." Still, Walker says biomass has great potential. "People want to be independent. They want a choice. Now more than ever they want to know where their money is going." But, while large-scale adoption of biomass energy might require new technology and infrastructure, consumers have a number of options today:

■ CORDWOOD STOVES

Wood stoves balance performance and cost. The best stoves are 60 to 70 percent efficient at converting well-seasoned wood into heat. At an average price of $200 per cord, firewood is one of the cheapest fuels per unit of heat. Prices tend to rise and fall along with fossil-fuel heat sources, but because wood is sourced locally, the shifts in cost are less dramatic.

Wood is cheaper if you harvest your own. Jerry Marquez, a homebuilder in Libby, Mont., heats his two-bedroom house for about $200 per year, but he spends a couple of grueling weeks each spring harvesting and splitting standing deadwood in Kootenai National Forest. Like Richards, he shovels ash from his stove weekly. It's hard work, but the price is right, and Marquez says he loves the way the flames crackle in his Enviro Kodiak 1700 stove, warming his living room and kitchen on subzero Montana mornings.

Marquez's house is small enough to get by on what is essentially a 74,000-Btu room heater. Lee Richards heats his larger Virginia ranch home by strategically installing multiple wood stoves to blanket the house in heat. But the stoves cost $3000 to $4200 each (including flue installation). So pushing a single stove to its limit can make more economic sense. "You have a nice toasty living room and kitchen and maybe the edges of your home are a little chilly at five o'clock in the morning," says Charles Niebling, a forester in New Hampshire.

Wood stoves have become much cleaner since the EPA began regulating their maximum particulate emission levels. Stove manufacturers first added catalytic combustors—tubes with honeycomb chambers coated in a corrosion-free noble metal, usually palladium. Similar to catalytic converters on cars, these turn exhaust gases into heat. Catalytic-combustion stoves have been improved by a new process called secondary burn, which converts wood smoke to heat, drawing extra fuel from logs and boosting stove efficiency.

Another option is a masonry stove, sometimes known as a Russian stove. These built-in units resemble freestanding fireplaces made of dense stone or brick, with snaking channels leading from the firebox to the chimney. The channels maximize the transfer of heat from the gases to the surrounding masonry, allowing the stoves to store and radiate warmth from very hot fires for long periods. They are efficient and clean-burning and require less stoking, though they are expensive because they are almost always custom-built. Installed prices range from $13,000 to well above $20,000.

■ PELLET STOVES

Owners of these stoves can't harvest their own fuel, but what they give up in price and freedom they gain in ease of use. A $250 ton of pellets yields three-quarters of the heat generated by a cord of wood, yet pellet stoves operate at higher efficiency rates—usually around 80 percent. Thermostats allow some pellet stoves to automatically control temperature and heat output.

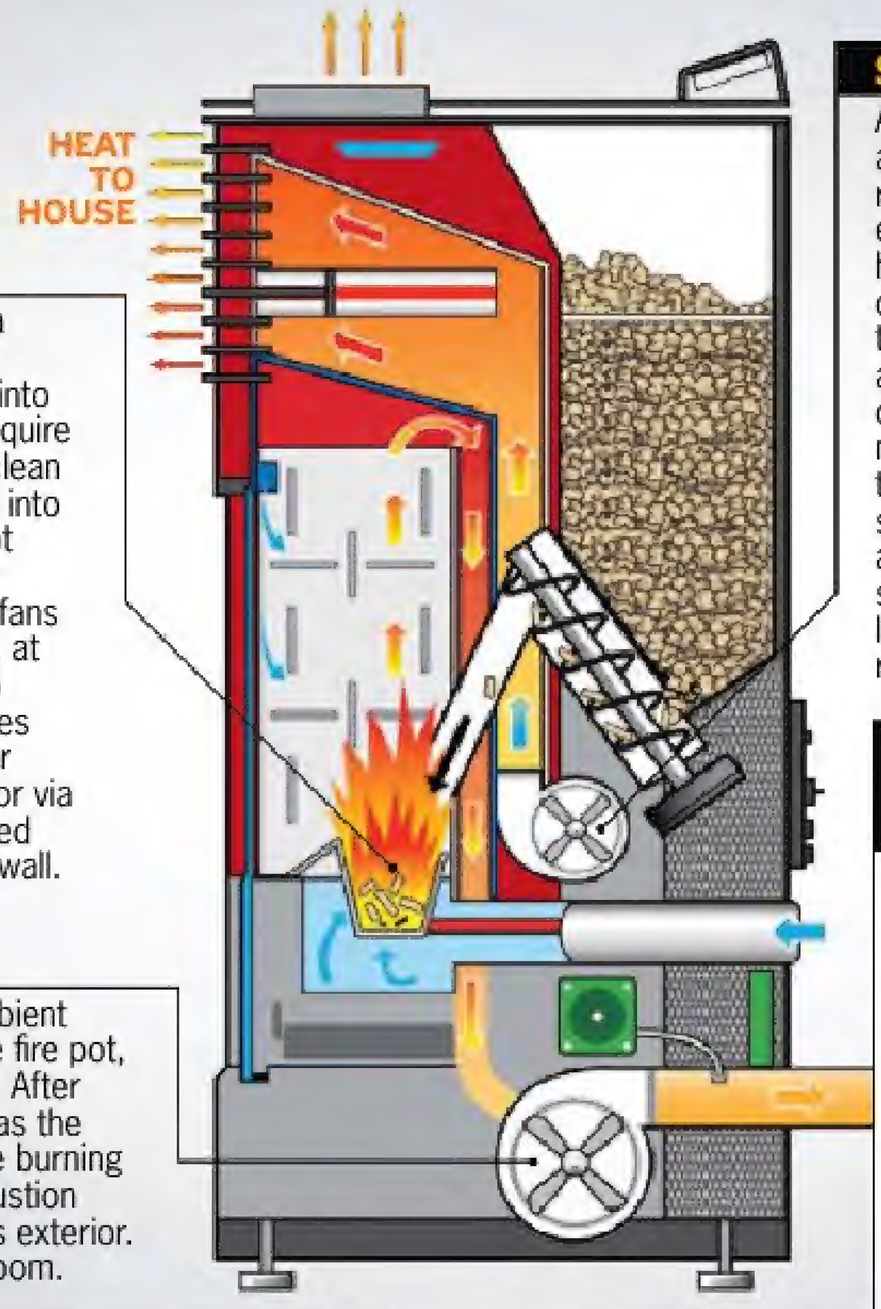
Pellet fuel offers many advantages over cordwood: It has a moisture content of less than 8 percent, compared to 20 percent or more for seasoned wood and 50 to 60 percent for unseasoned wood. (Btus are wasted in vaporizing moisture.) Dry pellet fuel is inert and nontoxic. It has an infinite shelf

FOR YEARS, LIBBY, MONT., CHOKED ON WOOD SMOKE TRAPPED BY A WINTER TEMPERATURE INVERSION. REPLACING 1100 OLD STOVES WITH EFFICIENT MODELS, FROM 2005 TO 2009, REDUCED OUTDOOR POLLUTION LEVELS BY 28% AND INDOOR AIR QUALITY IMPROVED BY 72%.

Libby, Montana / April 2010

How Pellet Stoves Work

A typical free-standing 400-pound pellet stove produces just over 45,000 Btu per hour, enough to heat about 2250 square feet of living space. The average home burns 3 to 6 tons of pellets in a season.



STEP 1

Pellets loaded into a hopper are fed by a motor-driven auger into a fire pot. Stoves require pellets made from clean sawdust—dirt turns into a stove-clogging clot called a clinker. The auger and a pair of fans consume electricity, at a cost of about $65 a year. Exhaust gases require a vent, either into a chimney flue or via a direct conduit bored through an exterior wall.

STEP 2

A combustion fan draws the room's ambient air over a hot electrical coil and into the fire pot, igniting the pellets in about 10 minutes. After 15 to 20 minutes, the igniter shuts off as the auger continues to drop pellets into the burning fire pot. This same fan channels combustion exhaust gases into a vent to the home's exterior. Only clean, smoke-free air enters the room.

STEP 3

A convection fan pulls ambient air from the room across a heat exchanger, circulating hot air into the room. A computer-controlled thermostat adjusts the auger speed and convection-fan rate to maintain even indoor temperatures. Pellet stoves shut down automatically if the stove leaks, the door is left open, or the hopper runs out of fuel.

life, and it doesn't harbor bacteria, fungus, bugs or mice. Its energy density rivals that of coal, but it doesn't produce as much ash as either coal or wood. A high surface-to-volume ratio makes pellets combust more like kindling than logs. The pellets' standard size means they can be fed automatically by the turn of an auger. Once pellets enter the stove's fire pot, airflow is metered to maintain a steady burn. The hopper usually must be refilled daily. Efficient combustion produces particulate emissions levels of around 1 to 3 grams per hour—comparable to oil or gas.

Pellets are cheaper than oil, propane or electricity, and they don't cost much more than natural gas. But because of the recent collapse in the housing market, the number of lumber and furniture mills producing high-grade sawdust has decreased, driving the price of a ton of pellets from less than $200 to $250.

Jerry Whitfield, a former Boeing engineer in northern Washington, is tackling the price problem by improving stove technology. Whitfield is researching a next-generation stove that burns a variety of pellet types and grades, including pelletized grasses, straws, hay, rice husks, sugarcane bagasse, corn stover, even poultry manure.

"I can envision a future," Freihofer says, "where there would be the equivalent of a local community pellet mill. It would recycle everything from newspapers to yard trimmings to waste wood, the way a grist mill might have operated 150 years ago."

ILLUSTRATIONS BY **SHINGO SHIMIZU**

■ PELLET BOILERS

With the firepower to provide whole-house heat, these machines circulate hot water through radiators or force hot air through ducts. The results are comparable, in performance and efficiency, to oil and gas heat.

Like pellet stoves, these are not as hands-off as fossil-fuel or electric appliances. Owners typically refill the hopper of a pellet boiler or furnace daily, although some models draw fuel automatically from large storage containers, much like an oil furnace draws from a tank. And they require ash dumping and an annual cleaning.

American companies, including Harman Home Heating, make pellet boilers and forced-air furnaces for around $6000, roughly double the cost of a comparable oil or gas appliance. The most advanced European central heating units must be custom-retrofitted to meet American Society for Testing and Materials (ASTM International) standards for use in this country, so prices crest at $20,000.

But if a shift toward biomass persists, boiler prices may begin to rival those of oil and gas appliances, according to New England Wood Pellet CEO Steve Walker. In restricting foreign boilers, he says, "we're keeping out the super-clean models that can build an industry here." With fuel distributed in bulk and fed into a boiler automatically from a basement tank, Walker's vision sounds as convenient as the heating-oil industry today. "It isn't entirely plug-and-play, but it's coming," he says. **PM**

THE EVOLUTION OF LIGHTING TECHNOLOGY IS CHANGING THE LANDSCAPE OF YOUR FUTURE.

CHECK OUT OUR MOST RECENT ISSUE ONLINE AT **WWW.DIGIKEY.COM/TECHZONE** AND ENJOY A BRIGHT FUTURE!

Your Source for Lighting

Digi-Key® CORPORATION

The industry's broadest product selection available for immediate delivery

Whatever your lighting technology, Digikey.com has the solid-state lighting components you need

www.digikey.com

1.800.344.4539

Supplier Authorized Distributors

Digital technology has come to define the modern Hollywood blockbuster. In movies such as *Tron: Legacy*, sets, vehicles and actors are a seamless blend of computer animation and live-action performances.

RACING THE FUTURE

DIGITAL HOLLYWOOD: SPECIAL-EFFECTS EPIC **TRON: LEGACY** *PAYS TRIBUTE TO THE PAST WHILE STRETCHING CURRENT MOVIE TECH TO ITS LIMITS. BUT ARE EXPERIMENTS WITH 3D AND COMPUTER EFFECTS HELPING OR HURTING HOLLYWOOD?*

BY ANNE THOMPSON ILLUSTRATION BY JEREMY COOK

FOR A MODERN HOLLYWOOD SCI-FI FLICK, THE MAKE-OR-break moment often boils down to an onstage audition in San Diego. That's where Comic-Con International, the yearly gathering of comic-book lovers, gaming enthusiasts and self-professed science-fiction nerds, takes place each July. It's also where big movie studios are becoming a larger and larger presence, eager to gather highly influential genre fans' advance reactions to upcoming films while there is still time for course corrections. But even by those standards, the 2008 screening of footage for a *Tron* sequel was an extraordinary exercise in early test marketing.

At the time, 34-year-old director Joseph Kosinski had no feature films and only a handful of commercials under his belt, and the 2½ minutes of footage he was about to show were from a movie that

3D VS 2.5D

BY ERIN MCCARTHY

TRON: LEGACY (2010)

GOOD 3D

When done right, 3D can be as much a part of the cinematic

didn't exist. There was no final screenplay, no studio green light—the movie didn't even have a name. Inside the San Diego Convention Center, 6000 people who had been listening to a panel discussion about the Disney film *Race to Witch Mountain* were asked to stick around for some "surprise footage." The title of Kosinski's clip summed up its status—"VFX Concept Test"—as just a few minutes of visual effects with no context. "If it had flopped," Kosinski says, "it could have killed the project."

On the screen, two futuristic motorcycles streaked out onto a neon grid, leaving glowing trails of blue and yellow light. Many in the audience hadn't even been born when the original film was released in 1982, but a cheer of recognition went through the crowd. The light cycles and glowing geometric cityscape were instantly identifiable as the environment of *Tron*—and the audience wanted more.

It was, in a way, a testament to the power of the original, a movie with a surprisingly parallel backstory. Three decades ago, a young animator named Steve Lisberger pitched the movie *Tron* by creating a 32-second preview with abstract, blocky computer-generated (CG) vehicles and an animated disc-throwing warrior. It demonstrated what he could do with the emerging computer-graphics technology of the time, and Disney greenlighted the movie. The hero of the film, Kevin Flynn, is a video-game developer who becomes digitized and gets sucked into a mainframe computer, then has to compete for survival in cyberspace and find his way back to the real world. *Tron*'s animation stretched the limits of the computers of the time, so the visual-effects team came up with a technological kluge: Part of the film was rendered on a supercomputer, while the rest was animated by hand.

Tron's stylized environments and high-tech looks were no match at the box office for 1982's real sci-fi blockbuster, Steven Spielberg's *E.T.: The Extraterrestrial,* but it's obvious now which of those films had more influence over the actual process of moviemaking. The puppetry and creative lighting of *E.T.* are becoming a lost art, while CG effects reign. *Tron* inspired a generation of animators to embrace computer graphics. Pioneers such as Pixar co-founder John Lasseter credit the movie as a major influence. "Without *Tron,*" Lasseter says, "there would be no *Toy Story*."

The original *Tron* arrived at a time of massive technological change in cinema. And whether by accident or design, the sequel born of the 2008 Comic-Con footage arrives at a similar inflection point. *Tron: Legacy,* which hits theaters on Dec. 17, moves the narrative of the original film forward 28 years, with Jeff Bridges, who played brash young programmer Flynn in the first movie, now reprising the role as an older, more meditative version of the character. The new movie pushes the technology forward as well. It is a single film that combines and refines almost every cutting-edge technique in cinema today: digital performance capture, advanced 3D cameras and sophisticated computer rendering of live actors into digital sets.

If any movie could succeed based on visual effects alone, it's *Tron: Legacy*. But the film also comes at a time of serious debate about the stresses such technology puts on the moviemaking process and its effect on the art of cinema. Shooting in 3D is expensive, the equipment is cumbersome, and

PHOTOGRAPHS BY EVERETT COLLECTION (*TRON: LEGACY, AVATAR, THE LAST AIRBENDER, UP*)

AVATAR (2009)

THE LAST AIRBENDER (2010)

BAD 3D

art as lighting, sound and set design, yet 3D done badly just adds a dimension of disappointment.

Nearly every moviegoer who has worn 3D glasses knows how great the format can be when utilized correctly (*Avatar, Up*) and how terrible it can be when slapdash conversions of 2D films go awry (*Clash of the Titans, The Last Airbender*). Now box-office trends are showing that audiences might be unwilling to pay as much as $5 more a ticket for substandard quality.

Stereoscopic trailblazer and *Avatar* director James Cameron is happy that consumers are lashing out against bad conversions. ***"Titans was a pretty good movie, but the 3D sucked,"*** he says. "It was sort of 2.5D. I want the studios to get spanked for making bad decisions."

As it turns out, manufacturing 3D from 2D footage is hard. Our eyes, set 2 inches apart, naturally allow us to perceive depth. When we look at a tree, for example, we can distinguish that one branch is in front of another. Shooting that tree with a stereoscopic camera rig would capture those different depths, but in a conversion every object must be placed in a depth plane. There are a number of ways to convert movies to 3D, says Hugh Murray, the vice president for technical production at IMAX. Some companies rely on automated computer algorithms, while others carve out objects and arbitrarily place them in different depth planes. Both methods can lead to underwhelming 3D.

At IMAX, conversion begins with segmentation artists, who draw precise outlines around the objects in a scene that will be in 3D; simultaneously, animators build wire-frame geometric models of those elements. The models allow converters to accurately set the objects' depth within the scene.

Next, a camera algorithm computes where the film pixels would be if they had been shot with a second camera, which generates the left-eye view. The areas that second camera would have seen had it been on set are filled in by hand-painting or, in visual-effects shots, with information from the original animators. All that's left to get the final shot is aesthetic manipulation. Murray says, ***"It's a combination of sophisticated technology, a lot of grunt labor and creative calls that go into making a good conversion."***

HOW TO SPOT A BAD 3D CONVERSION

● There's no real depth.

When you look at a scene in 2D, your eyes use perspective and relative size to determine depth relationships. But if the cues from the left- and right-eye images are different, there will be little to no depth in the scene.

● Objects wander around.

In real life, the objects closest to you move more quickly than distant scenery. If this motion parallax doesn't match in both eye views, objects will appear to change position in the frame.

● The depth planes are off.

Converters often misjudge where objects should be, which leads to one character looking past another or objects appearing as though they're part of the background when they should be in the foreground.

● The edges are incorrect.

Imprecise outlines leave parts of objects in the background—frizzy hair in particular—and make scenes look like early visual-effects shots, where lines appeared around things in composites.

Digital Fountain of Youth
For *Tron: Legacy*, visual-effects artists used multiple cameras rigged to 61-year-old actor Jeff Bridges's head to capture his performance. Then a "facial solve" computer program mapped his expressions onto a 35-year-old computer-generated version of him.

audiences seem increasingly picky about what movies they are willing to pay extra to see in 3D. Plus, risky experiments in CG and performance capture can end up unraveling the virtual environments visual-effects artists strive so hard to create. *Tron: Legacy* is the type of movie that can shape agendas in Hollywood. If audiences love it, *Tron* will become the new standard for innovation. But it only takes a few missteps to turn a technological tour de force into a cautionary tale.

3D or Not 3D

Given the success of films such as James Cameron's *Avatar* (nearly $3 billion worldwide and counting) and Tim Burton's *Alice in Wonderland* ($116 million opening weekend), 3D seems a no-brainer business decision for movie studios. Jeffrey Katzenberg of DreamWorks Animation and other studio executives have portrayed modern 3D technology as an evolutionary step in moviemaking, akin to sound and color. Theater operators have also bought into the technology in a big way—some 5000 digital cinema screens are now equipped with 3D projectors. Yet there are already signs of a growing backlash. Innovative directors such as Christopher Nolan (*The Dark Knight*) and Zack Snyder (*300, Watchmen*) have expressed concerns about the limitations of the technology and are making upcoming features in 2D. Studios have also pulled back on plans to release some high-profile movies in 3D. Last October, Warner Bros. changed course with *Harry Potter and the Deathly Hallows: Part 1* and decided to release it in 2D. Plus, audiences burned by shoddy 3D post-production conversions are voting with their wallets, opting for less expensive 2D versions or avoiding bad productions altogether.

Directors working in the medium certainly hope that audiences care about good 3D, because making stereoscopic movies can be a technical pain. Kosinski shot the actors in *Tron: Legacy* with an updated version of the same Pace Fusion 3D rigs James Cameron used for *Avatar,* outfitted with two Sony F35 cameras. "The Pace–Cameron F35 system is a very cumbersome beast on the set," Kosinski says. "It's such a large animal. It really informs the way you shoot." As a result, Kosinski went for longer, more static shots. Those shots, however, produce better 3D cinematography, giving more depth to each scene.

Much of the elaborate camerawork that is routine with 2D productions is intensely difficult with 3D, where precision is the coin of the realm. "We're really in the infancy of shooting 3D movies correctly," says Eric Barba, visual-effects supervisor for Digital Domain, which created the digital imagery for *Tron: Legacy*. "We're taking two cameras that aren't really intended to be together and linking them with a mechanical system. Five years from now, when they've designed a camera that just shoots stereo, this is going to seem like rubber bands and glue."

Capturing 3D footage on camera is only part of the process. Many of *Tron: Legacy*'s shots are 90 percent CG. During pivotal light-cycle races, for instance, actors rode bike rigs on a soundstage, then their movements were rotoscoped by computer and animated into a virtual environment that was completely computer-generated.

To directors such as Kosinski and Cameron, this immersive experience is what separates 3D as a cinematographic tool from 3D as a gimmick—a distinction they believe audiences can see and should care about. As *Tron: Legacy* producer Sean Bailey puts it:

"WE'RE REALLY IN THE INFANCY OF SHOOTING 3D CORRECTLY," SAYS ERIC BARBA, VISUAL-EFFECTS SUPERVISOR FOR *TRON: LEGACY*. "FIVE YEARS FROM NOW, THIS IS GOING TO SEEM LIKE RUBBER BANDS AND GLUE."

Your PC, simplified.

Windows 7

Toshiba Satellite® Series with Impact Smart Hard Drive.

Another common sense innovation
in a not so common sense world.
us.toshiba.com

TOSHIBA

Leading Innovation >>>

3D HOME GEAR

Big stereoscopic epics are Hollywood's way to get audiences back into theaters, but with the right technology, you can bring a 3D theater to your couch.

"When they come in to see a 3D movie, they should get what they pay for."

A Tale of Two Bridges

The premise of *Tron: Legacy* is ironically similar to the process of making it. Kevin Flynn has again been sucked into a virtual world of his own creation, and his long-estranged son, Sam (played by Garrett Hedlund), follows him into the software. Shortly after Sam enters the computerized game world of *Tron,* he comes face-to-face with his father, whom he hasn't seen in 20 years. Yet something seems off, since apparently his father hasn't aged at all. In the movie, it's a trick of the software—the real Kevin Flynn is trapped elsewhere in the program, while a younger-looking digital doppelgänger named Clu has emerged to become the virtual world's villain.

According to Digital Domain's Barba, turning the 61-year-old Bridges into Clu (modeled after Bridges at age 35) was "the most difficult thing that's ever been tried in visual effects." But it isn't entirely without precedent: For director David Fincher's 2008 movie *The Curious Case of Benjamin Button,* Barba prematurely aged actor Brad Pitt. Fincher used a similar effect in *The Social Network,* creating a twin of actor Armie Hammer by mapping his face onto a body double who acted alongside him.

As remarkable as those breakthroughs were, creating Clu was an order of magnitude more difficult: "Everyone has their own image of what they think Bridges should look like," says *Tron: Legacy* animation supervisor Steve Preeg. "It's very difficult to fool the human eye when it comes to seeing another human. We're such social animals."

Televisions:

Manufacturers such as Panasonic, LG, Sony and Vizio make 3D TVs—the ***Samsung UN46C8000 LCD ($2800)*** has performed well in PM's testing—and the 3D effect really does work. But expect to pay extra for early adoption: 3D sets tend to cost anywhere from 10 to 30 percent more than non-3D sets.

Glasses:

Shutter glasses are the biggest frustration of 3D home theater. They're expensive ($130 to $200), not always included with the set and incompatible from brand to brand. Monster Cable's ***Monster Vision Max 3D ($250, including transmitter kit)*** is one of the first attempts at universal glasses.

Players:

Most 3DTV manufacturers make 3D Blu-ray players, but a dedicated player isn't really necessary. Thanks to a firmware update, the existing ***Sony PlayStation 3 ($300)*** can play both 3D movies and games, and it costs less than most dedicated 3D Blu-ray players.

To turn back the clock on Bridges, Digital Domain relied on a similar but more advanced version of the head-mounted performance-capture camera arrays used in *Avatar*. Instead of Cameron's single-camera setup, Barba and his crew used four microcameras with infrared sensors to shoot the 143 spots dotting Bridges's face.

The actor performed each scene first, followed quickly by a younger body double who synchronized his movements. Then Digital Domain used a "facial solve" program to marry the facial expressions of today's Bridges (and his voice) with a digital actor modeled after the 35-year-old Bridges in 1984's *Against All Odds*.

The technology Digital Domain pioneered for Clu is a sign of things to come. Expensive cosmetic digital touchups of wrinkles and eye bags are already commonplace on big-budget movies. In fact, Preeg encourages actors to get themselves digitally scanned when they're young, so that effects people like him don't have to compensate for an actor's age in order to re-create him in a computer. Given the culture of everlasting youth that pervades Hollywood, it's easy to see how quickly the idea of ageless actor avatars could spread.

Is it worth the herculean effort involved to make such an intensive CG 3D epic? As a movie about the digital world, *Tron: Legacy* is a natural showcase for advanced technology. But it is possible to push the tech too far. Anything short of perfection will make the Clu character more distracting than compelling—indeed, negative reactions to early footage of Clu sent Barba and his team back to the shop, working down to the wire to refine the character.

Despite all the anticipation surrounding the movie, *Tron*'s stereoscopically filmed, motion-captured and digitally morphed star, Jeff Bridges, takes the long view of cinema technology. "Filmmakers are always looking for something to bring audiences deeper into the reality of the story," he says. "Isn't 3D without glasses coming in the next few years? Maybe that's where it's going. Or maybe you'll just take a pill . . . *Tron,* the pill." **PM**

ILLUMINATE your expertise

Visit our Lighting Solutions TechZone℠ today.

www.digikey.com/lighting

SAME-DAY SHIPPING
Orders entered by 8:00 pm
NEXT-DAY DELIVERY

Digi-Key®
CORPORATION

Each Digi-Key TechZone℠ offers expert and professional cutting edge solutions along with support, product information and training materials.

The industry's broadest product selection available for immediate delivery

www.digikey.com
1.800.344.4539

Saving Louisiana

A new slate of re-engineering projects must revive stressed coastal marshes without disrupting a centuries-old way of life.

By T. Edward Nickens
Illustration by Dogo

Brian Vosburg has to have a visual. An acoustic Doppler current profile, a multibeam bathymetry readout, a hydrograph—anything to help the geologist from Louisiana's Office of Coastal Protection and Restoration explain how the state plans to restore its tattered coast by tapping into the roiling brown Mississippi River, just 50 yards away. All he has on hand, however, is a chunk of gravel.

Hunched down on the river levee at Myrtle Grove, 25 miles south of New Orleans, Vosburg scratches into the concrete a schematic diagram of a U-shaped notch in the embankment called a river diversion. It is designed to spill water dense with sediment—the lower Mississippi carries about 150 million tons each year—into the disappearing marshes south of Myrtle Grove. In turn, the sediment will create new land that will sustain wildlife and seafood resources and buffer human communities from the ravages of storms.

Senior project manager Andrew Beall watches his colleague carve the visual aid. "What we do here will move the science and engineering of coastal restoration into fast-forward," Beall

5 Key Restoration Projects

Louisiana is desperate to rebuild an ecosystem rich in human and natural resources. Here are five projects designed to create new wetlands in critical areas.

Bayou Dupont Sediment Delivery System

Excavation of canals for navigation, oil and gas helped transform Bayou Dupont from wetlands to open water. This $26 million project, completed in May 2010, used pipelines to transport dredged river sediment, replenishing existing marsh and creating 577 acres of new land.

Lake Hermitage Marsh Creation

Experts estimate that without intervention one-third of this intertidal wetland will vanish by 2050. The $38 million project, which begins construction this year, will pump hydraulically dredged river sediment onto degraded marsh, creating 593 acres. Dikes will protect the shoreline, and nearly 5 miles of terraces will reduce turbidity.

Little Lake Shoreline Protection

To counter shoreline erosion and subsidence, this $29 million project, completed in 2007, has begun rebuilding 3000 acres of fragile marshes in the Barataria Basin with a 24-inch dredge pipe that deposits lakebed sediment onto wetlands. Shoreline dikes extend for approximately 4 miles. Benefits over the past four years: 488 acres created and 532 existing acres maintained.

Barataria Basin Land Bridge

This $34 million project, completed last March, uses hydraulically dredged material to nourish 1534 acres of natural levee ridges, swamps and freshwater marshes and will eventually create 1246 new acres of marsh.

Lake Pontchartrain

New Orleans

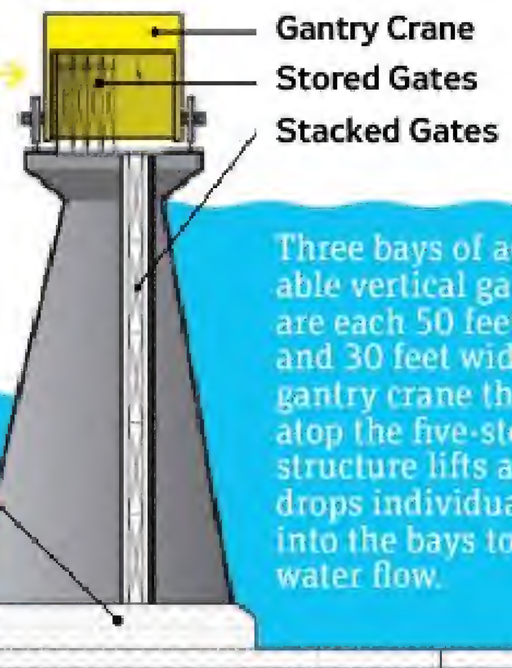
Mississippi River

Gulf of Mexico

Myrtle Grove Diversion-Control Structure

Adjustable Vertical Gate

(side view)



Three bays of adjustable vertical gates are each 50 feet high and 30 feet wide. A gantry crane that rolls atop the five-story structure lifts and drops individual gates into the bays to adjust water flow.

Myrtle Grove Water and Sediment Diversion

Unlike other coastal restoration projects, many of which involve dredging sediment from the Mississippi and transporting it as slurry in pipelines to rebuild wetlands, Myrtle Grove will divert up to 45,000 cubic feet per second of sediment-laden water onto depleted marshes. A 90-foot-wide structure (above, left) with three bays of gates will control the flow.

says. "If we can't think big now, we'll lose our chance."

For eons, the Mississippi River meandered across its low-lying delta, leaving fertile deposits of sand, silt and nutrients. For the past two centuries, however, engineers have tried to tame the waterway by raising levees to prevent flooding, straightening and deepening channels to aid navigation, and building complex control structures to regulate flow. Now, instead of spilling over its banks during spring and summer floods, the river and its precious cargo of sediment jet straight into the Gulf of Mexico, starving the coast of life-giving soils.

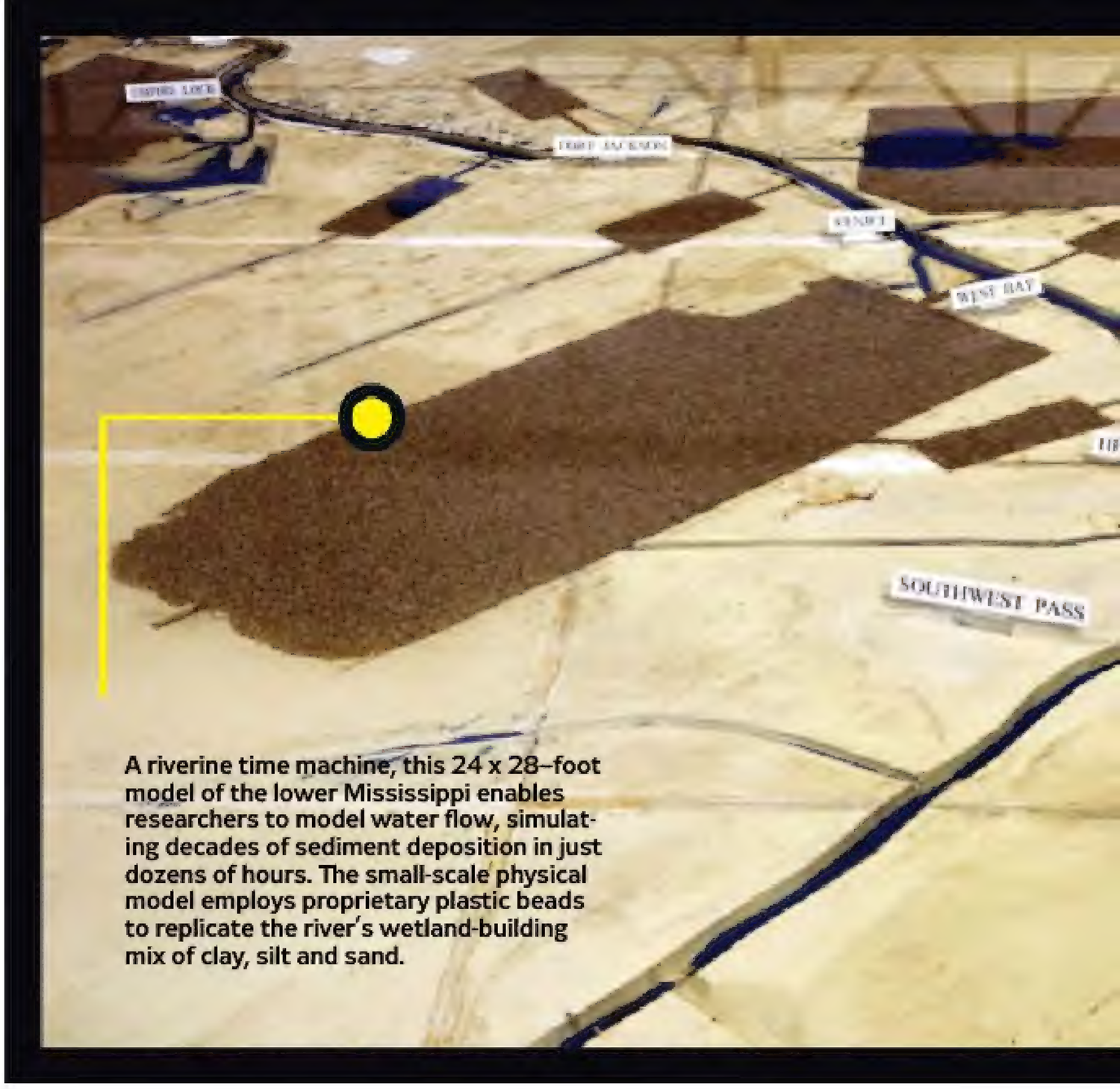
As a result, 1875 square miles of wetlands vanished in the 20th century. Marshes fell apart like rotting cloth. Beaches drowned. Open water winked in the sunshine where crops once grew. Experts estimate that in the first half of the 21st century another 673 square miles will be lost.

To restore the ravaged coast, scientists, engineers and conservationists are lining up behind a slate of engineering projects, including dredging that will move tons of sediment through miles of pipeline, and local programs to hand-plant marsh vegetation stem by stem. None, however, seem to hold as much promise as large-scale river diversions. Or generate as much controversy.

For years, Louisiana has operated small freshwater diversions, but they are designed mainly to blunt saltwater intrusions into marshes. Vosburg is part of a team that is studying the feasibility of notching levees to capture flow at high-water levels when the river is thick with suspended sediment. "Diversions to move sediment to create emergent land—that's a new paradigm," Vosburg says.

Proponents of coastal restoration have suggested super-sizing the diversion at Myrtle Grove—authorized in 2001 to operate at a modest 15,000 cubic feet per second (cfs)—and similar projects. The Environmental Defense Fund, the National Wildlife Federation and other organizations have suggested diversions of more than 100,000 cfs.

As Louisiana's scientists and engineers rush to fix the coast, however, they are struggling with another law of nature: the human dimension of ecosystem restoration. The idea of large-scale freshwater flows through the marshes is anathema to many residents. Such diversions could radically alter natural and human communities. Huge plumes of river water could create new trophy fishing grounds for largemouth bass anglers but also lower salinity to levels intolerable to Louisiana's famous speckled trout. Oyster companies might be shuttered, shrimpers driven farther south. "Large-scale river diversions in the wrong place mean you're talking about wiping out communities that have been here for a couple of centuries," says Kerry St. Pé, program director of the Barataria-Terrebonne National Estuary Program, a federal restoration initiative that works in 4.2 million acres between the Mississippi River and the Atchafalaya River to the west. "What we do about diversions will determine the future of coastal Louisiana."



A riverine time machine, this 24 x 28–foot model of the lower Mississippi enables researchers to model water flow, simulating decades of sediment deposition in just dozens of hours. The small-scale physical model employs proprietary plastic beads to replicate the river's wetland-building mix of clay, silt and sand.

In a tall metal building on the outskirts of Baton Rouge, the Louisiana Office of Coastal Protection and Restoration and Louisiana State University (LSU) operate a Lilliputian version of the lower Mississippi. The 24 x 28–foot small-scale physical model replicates the river's final 84 miles through 3526 square miles of wetlands and estuary. Fitted with scaled sediment diversions, it allows researchers to fast-forward through time—it takes only 50 hours to model a century's worth of river flow.

"As computational power increases, there's a tendency to sit at a desk and rely on numerical modeling," says Clinton S. Willson, an LSU associate professor of civil and environmental engineering. "With our model, we can see what is happening to the sediments across the landscape." Willson has his hands on a dial that regulates water flow through the miniature Mississippi. To simulate sediment transport, precise amounts of plastic beadlike sand are added to the discharges.

With the river flowing at a simulated 435,000 cfs, the sky-blue beads hug the bottom of the channel. "You can see there are no suspended sand-size particles," Vosburg says, his eyeballs inches from the water. "Try 750,000."

When Willson turns up the river, particles begin to vibrate, then roll along the bottom. Other particles race downstream in inky blue plumes and screw-like helixes. Choreographing this dance is critical to designing systems that capture the maximum amount of suspended clays, sands and silts. At what flow rate do sand grains experience "liftoff" from the river bottom? When does saltation—the bouncing, leaping movement of individual grains that bump into one another to create a cascade of sediment flow—begin? "We're dealing with a multitude of intricacies," Vosburg says.

He could be referring to the complex model, or to the complicated process of getting dirt out of a real river. Capturing sediment isn't as simple as unplugging a levee. Only at river-flow levels above approximately 600,000 cfs, a volume that can occur any time of year, do the heavier, coarser sands that are best for building new land rise to the upper strata of the river, where they can be siphoned off through the diversion and channeled to the marsh.

To calculate how much sediment might be available at Myrtle Grove, engineers deploy an ingenious array of monitoring technologies. Ship-based multibeam bathymetry paints a picture of gigantic underwater dunes rippling along the riverbed. Side-scan sonar maps the relative hardness of the bottom; a device using LISST (laser *in-situ* scattering and transmissometry) technology measures sediment volume. An Acoustic Doppler Current Profiler produces detailed imagery of water velocity, direction and magnitude in cross sections of the riverbed and reveals patterns of sediments. "We are literally and technically listening to the river and letting it tell us where the resources are," Vosburg says.

With such data, state officials hope to maximize sediment capture while minimizing the impact on oystermen, shrimpers, tourism and navigation channels in the nation's busiest river. "There's a tendency to latch on to the big numbers," cautions Andrew Beall, a keen observer at the model demonstration. "People think, 'At 100,000 cfs versus 15,000 cfs, we could do so much more.' But maybe we can do more with less, and use the science and engineering to minimize the amount of water that flows downstream of the project."

From the close quarters of a six-seater seaplane, Beall and Russ Joffrion, the state's lead engineer for the Myrtle Grove diversion, point excitedly at two creamy white patches set in the vast expanse of marsh and water below. They represent another option for coastal restoration—one that opponents of large-scale land-building diversions support because it doesn't affect water salinity. By dredging sediment from the river bottom and pumping it to specific sites, "sediment delivery dredging" can build land quickly. It took only 17 months to create the 2789 acres in one of the sand banks. Such dredging can be an impressive fix, but it is an expensive way to generate land that tends to be temporary.

The Myrtle Grove project would build a bridge of high ground between the two sandbanks, then—critically—nourish them with silts and clays. Joffrion's voice crackles in the plane's headset. "The diversion sediments sustain new land over the long-term."

It's a strategy that makes sense from 1000 feet above the marsh. Then an oyster dredge appears from under the plane's wing, with a Louisianan in an orange jumpsuit steering the boat through waters that might one day be home to a vastly different community of life. His place in the ecology and economy of a rebuilt Louisiana is an open question. "Whether we do nothing or whether we do everything, the future for south Louisiana is going to look different and function differently than what we have today," Beall says. "There are so many ideas to create new land and projects that nourish the land we've built at such great expense. This is the time to consider everything." **PM**

Geologist Brian Vosburg eyes the Mississippi near Myrtle Grove, south of New Orleans, where a diversion project will spread river sediments onto depleted marshes.

PHOTOGRAPHS BY **OFER WOLBERGER**

Popular Mechanics *TAKES YOU...*

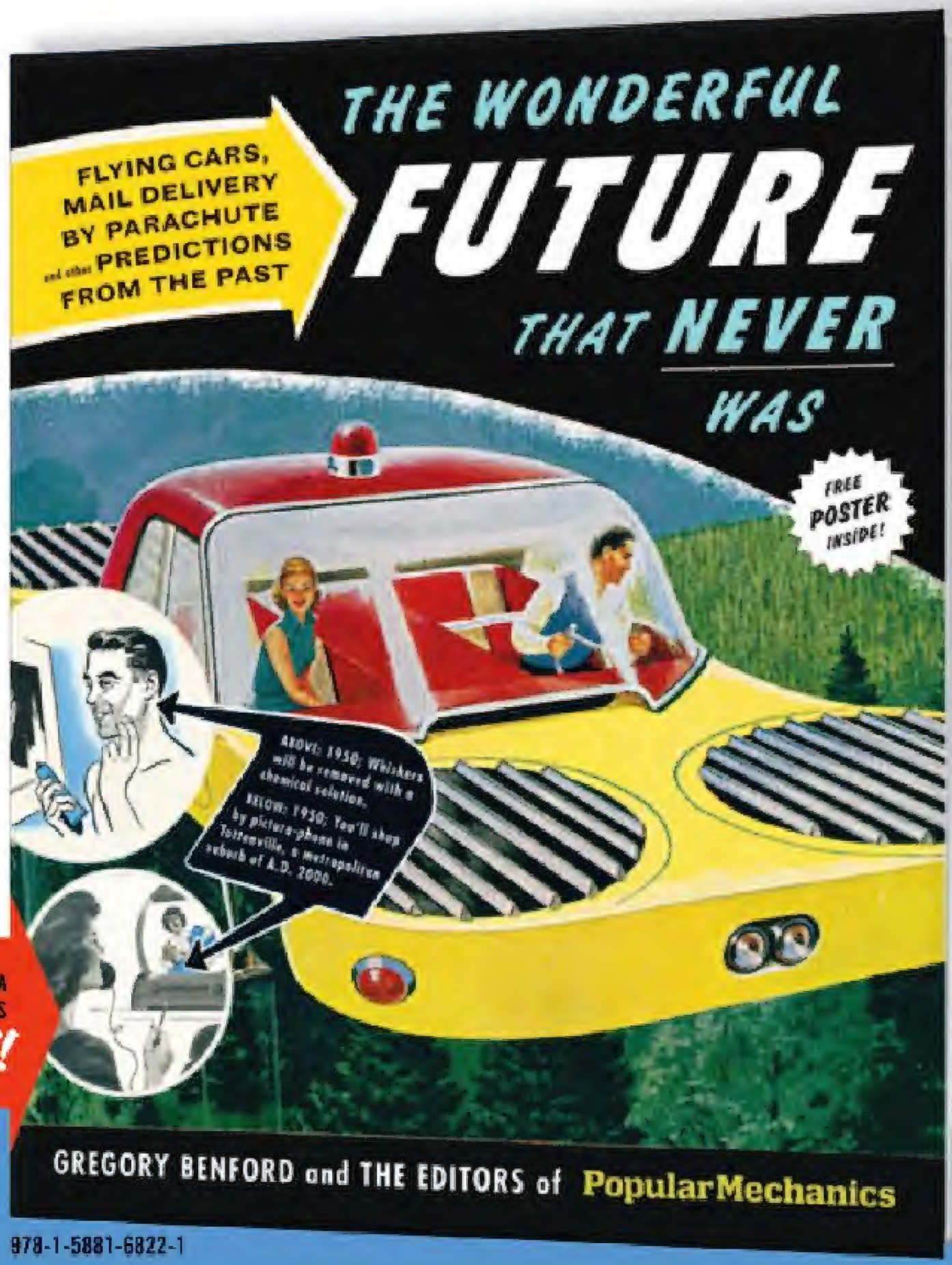
BACK TO THE FUTURE

1940. The torpedo-like rail car of tomorrow

Over the decades, scientists have peered into their crystal balls, envisioned the world to come...and shared their predictions with readers of POPULAR MECHANICS.

What did they see? Flying ambulances. Space suits made from paper. Utopian cities with elevated sidewalks and sunken streets. Even the cure for the common cold.

In our brand new book—a collection of these speculations with original text by Nebula winner and NASA advisor Gregory Benford—the bizarre, wildly imaginative, and (occasionally) eerily accurate WONDERFUL FUTURE THAT NEVER WAS comes to life.



978-1-5881-6822-1

BOOK JACKET FOLDS OUT INTO A POSTER FEATURING FABULOUS ***RETRO ART!***

$24.95 (CAN $31.95)
AVAILABLE NOW

Available wherever books are sold. Call 1-866-338-3778 to order or go to www.bn.com/wonderfulfuture

1950: Clean your waterproof home with a hose

HEARST BOOKS
An Imprint of Sterling Publishing Co., Inc.

diy **Home**

Roll Call

THIS CABINET ON CASTERS IS READY FOR ANY STORAGE NEEDS YOU MAY HAVE. *BY JOSEPH TRUINI*

Maybe we're bragging, but we think the PM rolling cabinet is about as versatile as furniture gets. It's a bookcase, a printer kiosk, a DVD-storage rack or a kitchen workstation. It's whatever storage you want, when and where you need it. Roll it from one place to another, set up shop, and move it again as required. We made the cart's shelves wide and deep to accommodate those baskets you see popping up in furniture catalogs and in showrooms. Don't like baskets? No problem—it works just as well without them.

Whether it's in the kitchen, den, home office or laundry room, PM's rolling cabinet stores whatever you need—wherever you want to store it.

INSIDE × CEILING LIGHT + HDTV ANTENNA + JUNKED-UP UTILITY ROOM

PHOTOGRAPHS BY **DANIEL SHEA**

Simplicity is a virtue, and this project is designed with that kind of goodness in mind. It's made of just 12 wood parts (see "Construction Details") and most of them are of the same material, red-oak plywood. You don't need more than a handful of tools: a circular saw, a router, a pocket-screw jig and a drill driver. You've probably got these already. All that remains is a free weekend. Frankly, you won't even need all of that time to knock out this cabinet. Here's how to build it.

Construction Sequence

Begin by ripping and crosscutting the shelves, the sides, the bottom and the top panel from red-oak plywood. Guide the saw with a straight piece of wood clamped across the panel, or use a clamping fence **[1]**. Clamp each side so that it's stable and you have access to its edge. Cut a rabbet along the back edge of each side panel using a router and a ball-bearing rabbet bit **[2]**.

With the sides ripped and rabbeted, iron on the veneer tape along their front edges **[3]**. Let the veneer overhang the ends, and trim it to length using heavy-duty scissors or sheet-metal snips. The heat-activated glue on this veneer is very strong, but you still need to ensure the tape is properly bonded. To do this, burnish the tape using a block of wood. Finally, shave the veneer to width using a file. Tip the file at a shallow 5- to 10-degree angle, and push it so its edge (not its face) cuts away excess veneer **[4]**. Veneer the shelves and the case bottom in the same manner.

Next, build up the top's front edges using short pieces of pine blocking. Crosscut the pine pieces and place them carefully so that the top can drop neatly over the case sides. Then fasten them using glue and 3d finishing nails **[5]**. Apply 2-inch-wide red-oak veneer tape to the ends first, and then tape the front edge. Iron the tape on, burnish it, and trim it just as you handled the sides.

Bore pocket-screw holes into the underside of each shelf and of the bottom panel **[6]**. Next, drive coarse-


1


2


3

[1] Rip and crosscut parts with a 40-tooth thin-kerf blade in a circular saw. Guide the cut with a straightedge. **[2]** Clamp a straight piece of scrap to the panel's edge to give the router a wide base to ride on. Cut the rabbet into the panel's edge. **[3]** Use a laundry iron on the dry, high-heat setting to apply veneer tape.

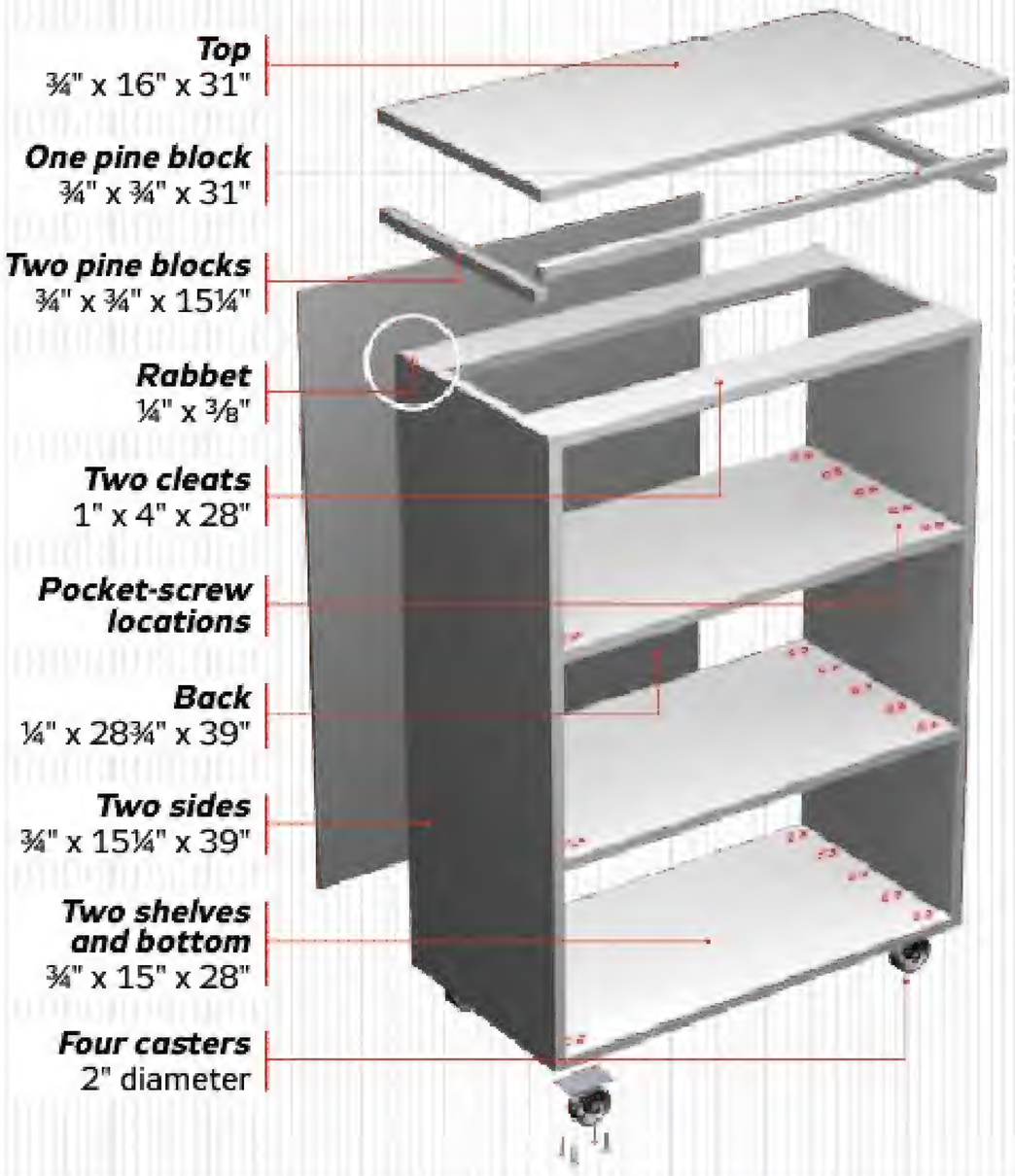

4

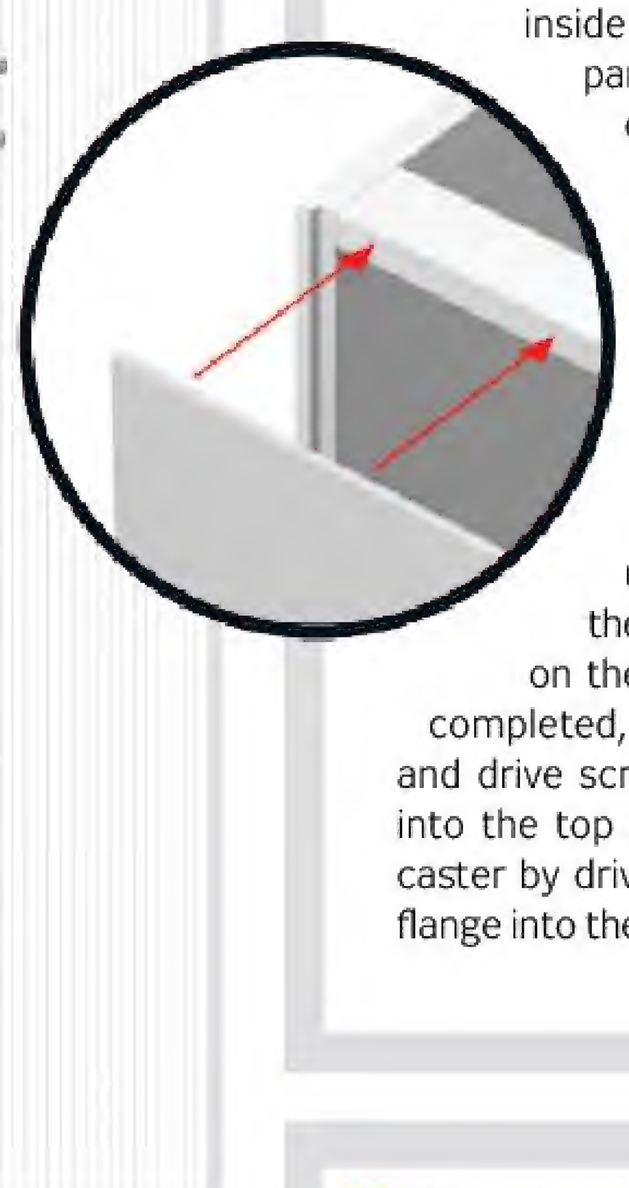

5


6

[4] Use a single-cut mill bastard file to shave off excess veneer. **[5]** Build up the thickness of the top panel by gluing and nailing pine blocks along its edges. **[6]** We used a Kreg jig to bore pocket-screw holes in the shelves and bottom. Simply clamp the parts in the jig and bore the holes.

[7] Use a specialized pocket-screw-driving bit to attach the bottom and shelves to the case sides. **[8]** Once the top is built, stained and finished, attach it by driving screws through the cleats and into its bottom surface. **[9]** We used rugged, solid-aluminum casters on this project. Screw the flange to the case bottom.





thread pocket screws through these parts and into the case sides. Begin by attaching the case bottom **[7]**, and then move on to the shelves. Next, crosscut the cleats to fit between the sides, and attach the cleats by driving screws through the case sides. There's no need to conceal these screws since the top will cover them.

Rip and crosscut the plywood back to fit the space between the rabbets and match the case length. Apply a coat of satin polyurethane to the front of the plywood back. Make small pencil marks on both case sides to indicate the center of each shelf, the bottom and the cleat. Place the back in the case, and draw lines across its back to indicate these centers. Nail along these lines to fasten the back to the sides, bottom and cleat.

Finally, lightly hand-sand all parts with 120-grit abrasive paper, wipe off the dust, and apply a coat of satin polyurethane to the shelves and to the inside and outside of the side panels. When the coating is dry, lightly sand these parts with 220-grit abrasive paper. Wipe off the sanding dust and apply a second coat. Apply a coat of ebony stain to the top. When the stain is dry, apply two coats of polyurethane to the top using the same method you used on the case. When the top is completed, drop it over the cleats and drive screws through the cleats into the top **[8]**. Finally, attach each caster by driving screws through the flange into the bottom **[9]**. **PM**

Construction Details

Parts Being Joined	*Fasteners*	*Direction of Fasteners*
Pine blocks and top →	1¼-inch (3d) finishing nails	Through blocks into top
Cleats and top →	1¼-inch coarse-thread drywall screws	Through bottom of cleats into top
Cleats and sides →	1⅝-inch coarse-thread drywall screws	Through sides into ends of cleats
Back to sides, shelves and bottom →	¾-inch wire nails	Through back into side rabbet, shelves and bottom
Shelves, bottom and sides →	1¼-inch coarse-thread pocket screws	Through shelves into sides; through bottom into sides

ILLUSTRATION BY GEORGE RETSECK

Homeowners Clinic

Q+A

by Roy Berendsohn

A lot goes into a successful ceiling-light installation, even in a relatively new home. First, check the house wiring. Next, ground both the fixture and its mounting bar. Install bulbs with a wattage no higher than the wattage rating listed on the fixture. Finally, install the globe.

Hit the Ceiling

I'm pretty handy, but I've never tried an electrical job, even a small one. I want to replace a couple of ceiling-light fixtures. They're not worn out or damaged—the house is only eight years old. The lights are just ugly. Do you have some advice to get me started?

A There's a first time for everything, and I think you should be able to handle this. I'm assuming that you're talking about a light fixture operated by one single-pole switch. Things can get complicated with any one of these: a house with old wiring, a chandelier, a lighted ceiling fan, multiple lights operated by one switch or a light operated by multiple switches.

First, read the directions. That might seem obvious, but, according to Rockford, Ill., electrician Bill Lego, a walking textbook of hard-won knowledge, a lot of people skip that step. Next, kill the power to the fixture. "I've known some guys who like to wire hot," Lego says. "They handle the wires like they're tiny venomous snakes. This is not a good idea." Cutting the power by simply flipping the wall switch can also get you into trouble. If a switch is incorrectly wired so that it breaks the neutral wire instead of the hot, the wiring in the junction box will still be hot, though the switch is off. So turn off the associated breaker, and check that the wires are dead using a noncontact voltage detector. Move this pen-like tool above the wires. If there's voltage present, the detector will light up and beep. No, it's not an exotic electrician's gadget; you can get one at any home center or well-stocked hardware store.

Now that the circuit breaker is off and you're sure the wires are dead, drop the light down and untwist the two wire connectors that make the splices to the lamp's wires, plus the connector making the connection to ground. Before installing anything, verify that the house's wiring was done correctly. In a newer house like yours, it probably was—but if it wasn't, you could wire the fixture so that everything looks correct and still receive a shock from the outside of a metal bulb socket. First, switch

PHOTOGRAPHS BY **DANIEL SHEA**

the circuit breaker back on. Using a multimeter set to read alternating-current voltage (or VAC), carefully check for voltage. You should find 120 volts between the black wire and white wire (neutral). You should get the same reading between the black wire and ground. The last check should show 0 volts between the white wire and ground. If you find that the readings are reversed, call an electrician. (To avoid confusion, see "When White Means Black," below.) Now turn the circuit breaker off.

If you're installing a rewired vintage fixture, it's wise to check that it's correctly wired as well. Obviously, you want to find out if the fixture is defective before you install it, not after. The fixture's wires will either be color-coded to match the house wiring (white and black), or they will both be black. In the latter case, the neutral wire will have a small groove or ridge on its surface.

Set the meter to read resistance (ohms), and place one meter probe against the center contact at the base of any socket. Touch the other probe to the conductor wires from the lamp, one at a time. You should get 0 to 0.5 ohms on one of the wires. This is the hot wire that you'll connect to the hot wire from the house circuit. The other insulated wire is the neutral, and the meter should indicate "open" when you check it. (Note: Meters indicate "open" for an incomplete circuit using several different symbols, such as OL for overload; consult your meter's manual to find the symbol it uses.) The fixture's neutral wire is connected to the house's neutral. If the fixture has a ground wire, check that also. The same meter reading from the center socket contact to the ground wire should also be open.

Assuming all tests have shown correct wiring, splice the lamp's wires to the house wiring. Be sure to correctly ground the fixture. To do that, take a small length of copper wire (a "pigtail") that's the same gauge as the house wiring, bend one of the ends into a hook, and place that end clockwise under the grounding screw on the metal strap across the face of the ceiling box. Tighten the screw. Use a twist-on wire connector to splice the grounding wires from the house and the lamp onto the other end of the pigtail.

Finally, strip the ends of the lamp wires to be spliced, line them up with the wires from the house so they are parallel, and firmly twist on a wire connector. No exposed wire should show beneath the connector. Install the bulbs and mount the globe, and you've safely completed your first electrical job.

Left Hanging

We have a nice old barn with picturesque doors. They hang down from hardware that looks like horseshoes and rolls along a track. The track is sagging, and the doors have large gaps between them. We want to repair the track without taking the doors down, because we're afraid that if we damage their hardware we won't be able to replace everything. The doors just won't look the same hanging from a modern track. Please help.

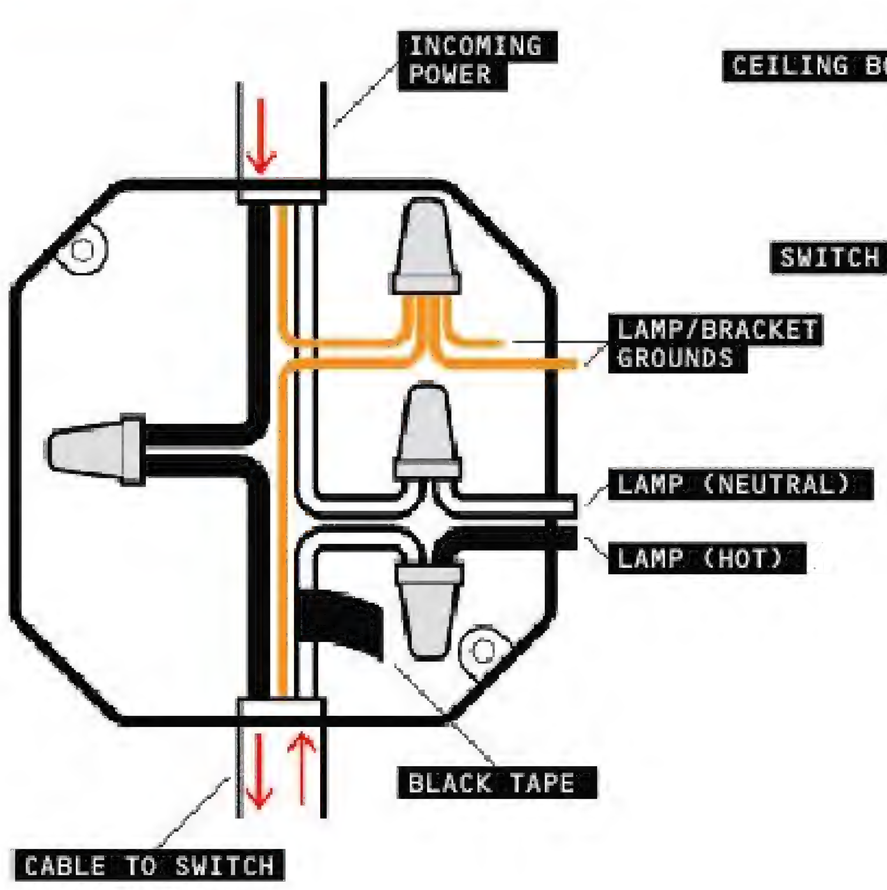
Take the doors down and repair the setup. Don't try the repair with the weight of the doors hanging from the track. Even if that were possible, it sure would be frustrating. Besides, the doors that you describe are traditional barn doors and are meant to be lifted off the track for repairs. Take them down, and straighten the track if possible. If that's not possible, you can get traditional barn-door hardware at *barndoorhardware.com* (proving yet again that there's a website for everything).

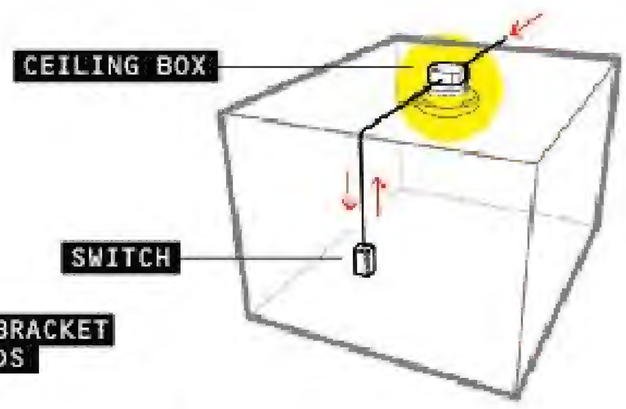
Furnace-Room Hoarder

I want your opinion. My husband's got all kinds of stuff stored in the utility room. The room's the size of a large closet, and the furnace and water heater are in there. I think it's

ELECTRICAL BASICS

WHEN WHITE MEANS BLACK





→ Wires are color-coded for safety reasons. In most situations (though not all), you splice together like-colored wires: white to white, black to black, bare to bare (or bare to green).

But sometimes you open a ceiling box and find a white wire spliced to the fixture's black (hot) wire. This is electrically correct but visually confusing. In those rare instances when a white wire is used to carry current to a load (instead of away from the load), the National Electrical Code requires that the wire be marked with black electrical tape or paint.

Often, the white wire has not been marked, and this adds to the confusion. Just remember to keep to this white/black splice when you install the new fixture. Of course, if the white wire hasn't been marked, then do it yourself. That will serve as an immediate visual cue to the next person who changes that fixture. — *R.B.*

ILLUSTRATION BY GEORGE RETSECK

dangerous. He thinks it's okay. Who's right?

You are. A utility room is not a closet. Stuffing it full of junk interferes with proper airflow to gas- and oil-combustion appliances if they take combustion air from inside the house. And if there's a problem like a dirty burner, a partially blocked flue or excessive gas pressure, the overcrowding can cause an appliance's burner flame to roll out from the cabinet (especially if a service-access door is partially open or removed). This can quickly ignite all your husband's junk—and the house. Now, modern heating appliances have a flame rollout switch designed to detect this danger and shut the appliance down. But relying on that switch is like storing gasoline in an upstairs bedroom and saying, "Don't worry, I've got a fire extinguisher." Forget it. Keep the utility room clear.

Aside from that, rummaging around in a utility closet to get at tools, equipment, boxes or cleaning supplies can cause you to bang into controls, condensate lines, valves, switches, direct vents and junction boxes housing electrical connections.

Finally, stuff piled in a utility room can conceal a water leak from a water heater (or boiler) until a lot of damage has been done. Bottom line: You're right. He's wrong. The junk has to go.

NOW YOU KNOW

It's in the Bag

→ A toolbox is a dark and dirty place. Metal chips, sawdust, drywall dust and all kinds of sharp and nasty things are rolling around and grinding away in there. If you've got something to keep clean—like electrical tape, contact tips for your wire-feed welder, or tubes of specialty lubricants—keep them in a sealable plastic bag. Now you know.

Spiraling Down

We want to finish our attic and join it to the floor below with a spiral stair. Is this allowed?

You can probably use spiral stairs, as long as they conform to a town's building code. The International Residential Code, for instance, permits spiral stairs, but they must have the right dimensions for tread width and handrail location and obey some other rules. Stair manufacturers pay close attention to these code requirements, so I doubt you'll have trouble finding stairs you like that satisfy the code. The best idea is to include the manufacturer's dimensions when you submit your plans to the building department.

Now, I'm not saying you can expect the town to simply rubber-stamp your plans. If you intend to use the finished attic as a bedroom (or even if the space *could* be used as a bedroom), building

PHOTOGRAPH BY RICHARD MAJCHRZAK/STUDIO D

officials may have something to say about the width and size of the stairs. (They'll also require at least one window big enough for emergency access.) "Do your homework with the local building department before you begin the project," Jeff Geary, an architect in Staten Island, N.Y., says. "You don't want officials telling you that your stairs are not permitted after they're installed."

Before you commit to installing spiral stairs, understand that they're not for everybody. They're steep and difficult to navigate in the dark or while you're carrying something. They're also no place for little kids. You lose considerable floor space when you use conventional stairs, but sometimes that's a swap you just have to make.

Ducts in a Row

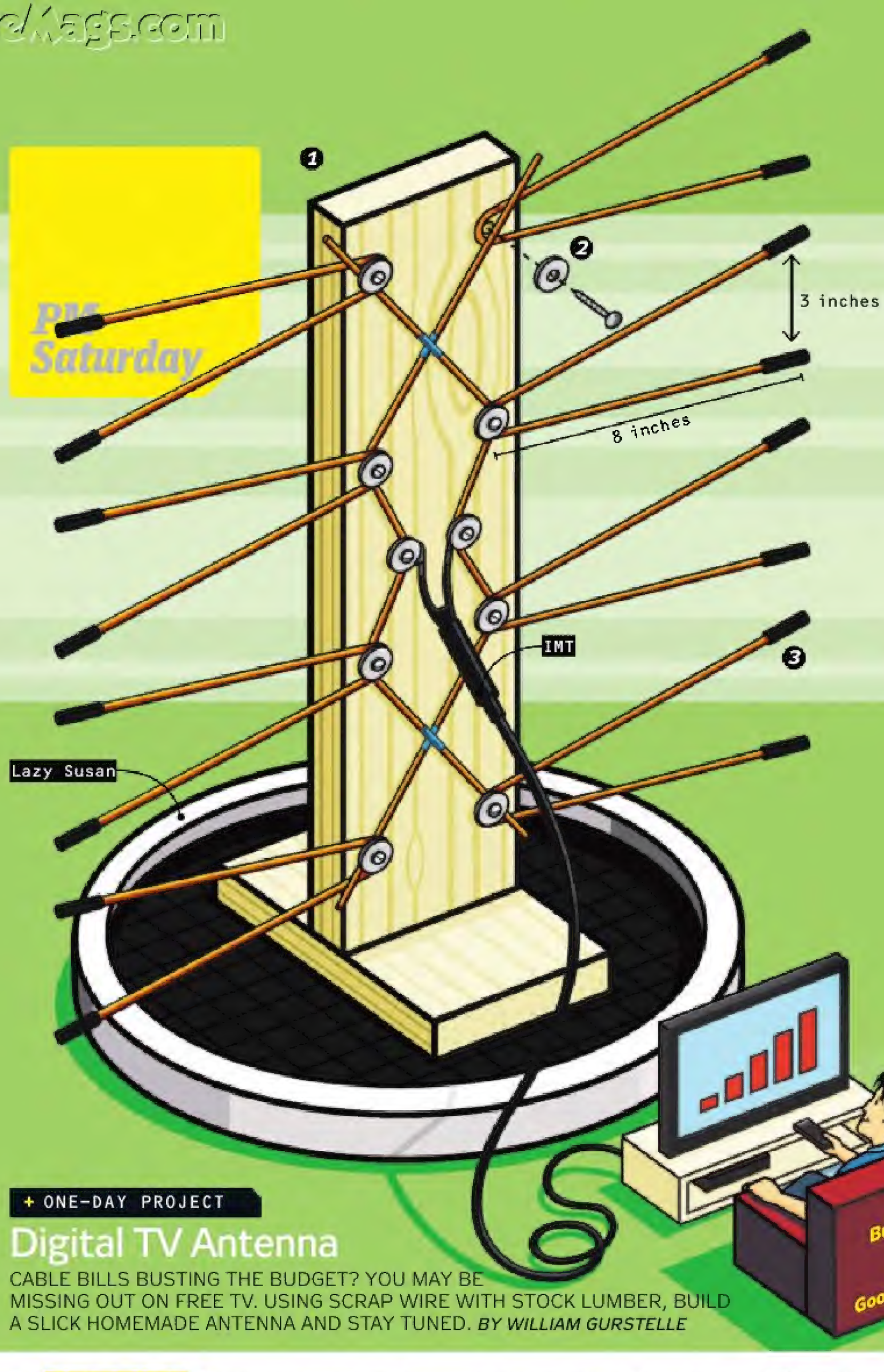
We live in a town house with a long run of dryer duct leading from the laundry room to a vent on an outside wall. We clean the dryer screen after every load, but I'm still concerned about a lint buildup in the duct. What's the best way to keep it clean? I know it sounds weird, but a friend of mine uses a leaf blower. Does that work?

I've heard from several readers who use an electric leaf blower to keep their dryer vent clear; others use the exhaust from a shop vacuum. Neither the blower nor the shop vacuum is enough, however. You also need flexible cleaning rods that screw together, with a brush on the end. While you could cobble together your own system, it makes more sense to buy something like a LintEater system. It can clean a dryer duct up to 15 feet long. An accessory kit of four additional rods helps you clean longer runs.

Keep in mind that long runs of dryer duct are best cleaned from two directions: pushing lint from the inside and pulling it from the outside. **PM**

Got a home-maintenance or repair problem? Ask **Roy** about it. Send your questions to ***pmhomeclinic@hearst.com*** or to Homeowners Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we cannot answer questions individually, problems of general interest will be discussed in the column.

PM Saturday



+ ONE-DAY PROJECT

Digital TV Antenna

CABLE BILLS BUSTING THE BUDGET? YOU MAY BE MISSING OUT ON FREE TV. USING SCRAP WIRE WITH STOCK LUMBER, BUILD A SLICK HOMEMADE ANTENNA AND STAY TUNED. *BY WILLIAM GURSTELLE*

1 → GATHER PARTS This antenna spins to orient a pattern of wires, known as an array in engineerspeak, toward broadcasting towers. Rabbit ears and some other older antennas can't receive high-frequency digital TV transmissions (but if you have an old antenna, try it). To assemble this DIY design, get 32-inch- and 6-inch-long 1 x 4 pine boards; eight 17-inch lengths and two 34-inch lengths of bare 12-gauge copper wire (for the ears and phasing bars); heat-shrink tubing; and 10 No. 8 ½-inch round-head wood screws and fender washers. Buy an impedance-matching transformer (IMT) to maximize signal transmission from channels at different frequencies.

2 → BUILD THE ARRAY Bend the 17-inch-long copper wires into eight "ears," or acute angles, with 3 inches of space separating the ends. Lay the 32-inch pine board flat, arrange the ears, and thread the phasing bars from ear to ear, as shown. Fit each pair of wires beneath fender washers and drive in the screws. Wrap electrical tape around the phasing bars where they cross, to prevent contact. In the center of the array, fasten the IMT and both phasing bars beneath a fender washer and screw. Construct the base by attaching the 6-inch 1 x 4 perpendicular to the 32-inch board using coarse-threaded screws.

3 → WRAP IT UP Place heat-shrink tubing over the tips of the ears and use a flame or heat gun to shrink it tight to the wires. Use coaxial cable to connect a digital-signal-ready television or converter box to the transformer. Switch on your TV, orient the antenna, and enjoy the show.

+ MORE TO DO IN JANUARY

Tow Tools
→ Driving this winter? Carry these emergency items in your trunk, advises New Hampshire State Police Capt. Chris Colitti: flares, blankets, ice scraper, shovel, axe, flashlight and jumper cables.

Shuck Oysters
→ At the 53rd Fur and Wildlife Festival, Jan. 7–8, in Cameron, La., learn Cajun skills as bayou men compete in trap-setting, oyster-prying and muskrat-skinning.

Bust Ice Dams
→ Well-insulated attics prevent ice dams. But if one forms and leaks, scale a ladder and use a roof rake to remove snow, University of Minnesota building systems expert Pat Huelman says. "Work from the ground. Don't climb on the roof. No snowblower."

Wallow in Mud
→ At the Winter Classic Swamp Buggy Race in Naples, Fla., watch custom jeeps go deep in the Mile-o-Mud run, Jan. 29–30.

Beat a Freeze
→ Prepare for an ice storm by treating pavement with brine. Russell Alger of Michigan Tech University's Institute of Snow Research adds hot water to a garbage can until it's 75 percent full, then "a whole bunch" of rock salt, stirring until it stops dissolving. Pour a thin coat before the big chill.

ILLUSTRATION BY **NATHAN DANIELS**

PM MARKETPLACE

To advertise in the PM Marketplace contact Beth Boyle at (914) 461-3269 or beth@specialaditions.com

diy

Auto

Saturday Mechanic

degree of difficulty
MODERATE

Chasing Vacuum Leaks

AIR LEAKING *INTO* YOUR CAR—NOT OUT OF IT—CAN BE A PROBLEM. *BY MIKE ALLEN*

As you've heard many times, your car's engine is nothing but a big air pump. It sucks in air that gets mixed with fuel, then compressed and ignited to produce the big boom that drives the wheels. Since few of us drive around with the throttle wide open—lest we draw unwanted attention—the engine is forced to draw air through a partially closed butterfly valve, which creates a vacuum in the intake manifold. Your car uses that vacuum to power and control a range of auxiliary devices. The brakes use

A device that produces a visible gas, like the Smoke Pro, is a useful tool for sniffing out hard-to-detect vacuum leaks.

INSIDE ▸ VACUUM LEAKS + SMOKE MACHINE + RADIATOR FIX

PHOTOGRAPHS BY **DENNIS KLEIMAN**

engine vacuum to reduce the pedal effort, and the emissions-control system relies on the negative pressure to prevent crankcase fumes from escaping. In the old days, engine vacuum even powered the wipers.

A classic from the muscle-car era might have just three vacuum lines: one each to the vacuum advance on the distributor, the power brake booster and the automatic transmission modulator. When emission controls started to proliferate in the late '60s, some cars had literally dozens of vacuum lines and connections, and any one of them represented a potential vacuum leak.

As car manufacturers started to understand emissions better, the number of vacuum lines diminished—but that didn't last long. The EPA started to require that leaking gasoline fumes be reduced to virtually zero, and the EVAP system on every current car is controlled largely by—you guessed it—engine vacuum. When the car is turned off, the system captures fuel vapor in a charcoal canister, then parses the vapors back to the running engine through—you guessed it again—a network of vacuum hoses.

When one of those hoses or fittings or joints starts to leak, the problems can range from an erratic idle to a sudden decrease in fuel economy to a Check Engine light. Some leaks—such as ones at the brake booster—are easy to detect, but others can be notoriously elusive. We're here to help.

Leaking Basics

Even a tiny leak, as small as 0.020 of an inch, can degrade engine performance, compromise driveability and turn on your Check Engine light. Here's why: A vacuum leak is downstream of the device that measures the incoming air—the mass airflow (MAF) sensor—which means the engine actually ingests more air than is measured and the computer gets an erroneous low reading. That raises the normal 14.7:1 air-to-gasoline ratio, causing the engine to run leaner than it would in normal operation. (The engine computer dithers the mixture ratio back and forth several times per second in the vicinity of that stoichiometrically correct 14.7:1.)

What about the exhaust-mounted oxygen sensor? Well, it will quickly detect the extra air, and in response the computer will richen up the mixture—it's a self-correcting, closed-loop system. Unfortunately, the leak may cause the nearest cylinder to run leaner than the others. The ECM will indeed richen up the overall mix in an attempt to bring the excess oxygen in the exhaust back to the appropriate low level—but that will force the other cylinders to be too rich, which may cause a whole menu of issues—misfires, unstable idle, etc.—that might set a trouble code and turn on the Check Engine light.

And with some vehicles using dozens of vacuum hoses, and the potential for cracks in multipart intake manifold systems, there are plenty of places for leaks to crop up. The ducting that runs between the throttle body and the MAF sensor, often 3-inch-diameter rubber, can also degrade. A leak in this duct

OLD-SCHOOL

THE CARB-CLEANER TRICK

Here's how we old-line mechanics learned to chase leaks: To keep the engine computer from richening up the mix, pull the wire on the throttle position sensor or some other handy sensor that will keep the engine in open-loop mode, where the computer just uses hard-coded default values for the amount of fuel instead of dithering the values around to stay near that golden 14.7:1 ratio.

This is analogous to the situation in a carbureted car (or motorcycle, or any other IC engine that doesn't have a computer). Start the engine and let it idle. Now spray aerosol carb cleaner onto the suspected leak. Yes, this is dangerous, especially if you consider your eyebrows important. There's not supposed to be an ignition source on the engine anywhere, but once in a blue moon, a stray spark or an overheated exhaust manifold can make the carb cleaner flare up. You've been warned.

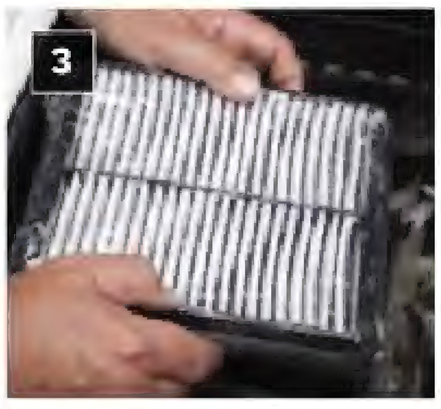
The combustible carb cleaner will be sucked into the leak, and the engine will pick up its idle speed momentarily—and probably run on all cylinders if it's been misfiring. We quickly learned to use short, directed puffs of carb cleaner to localize the leak.

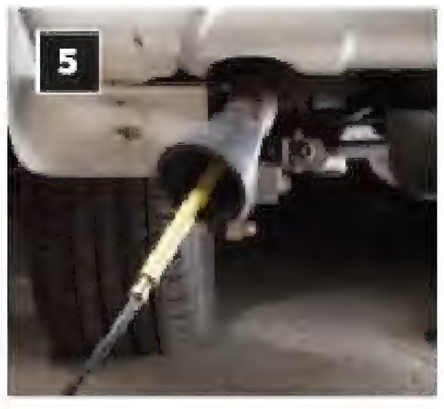
Another option is to use an unlit propane torch to prospect for leaks. A piece of hose shoved over the torch's valve outlet will let you poke around the engine bay. When the combustible propane is sucked into the lean-running engine, it will smooth out and speed up slightly. Similarly, you can spray water or motor oil onto a suspected leak and achieve the same end. When the water gets sucked into the leak, it momentarily interrupts the extra O_2 stream, and the engine's idle will change.

TOOL ENVY

SMOKING OUT LEAKS

It's a pro-grade tool, but a smoke generator makes chasing down vacuum leaks simple. These leaks tend to come in bunches, since rubber hoses and plastic vacuum fittings deteriorate as a car ages. Keep hunting until you've found them all.





1. Start a vacuum-leak smoking expedition by plugging up any obvious potential ports in the intake manifold, starting with the inlet to the throttle body from the air cleaner.

2. Connect the smoke machine's nozzle to the manifold. One good place is the large-diameter vacuum line to the brake booster.

3. A quick way to seal the inlet is to wrap the air cleaner in clingy food wrap, although this method is not as good as plugging up the circular rubber duct somewhere closer to the throttle body. (Don't forget to remove the plastic wrap when you're done, or the car won't even start.)

4. Hit the smoke button and give the smoke a couple of minutes to saturate the intake tract. Smoke coming out of the oil-fill port like this might be indicative of a bad crankcase vent system, depending on the vehicle. Check the manual to see if the PCV valve is a check valve or some other method for metering manifold vacuum into the crankcase. With a nice bright light, scout the engine compartment for any sign of smoke.

5. A leaky manifold gasket or a cracked header can also leak air into the exhaust system, fooling the oxygen sensors. A quick test is to fill the exhaust with smoke. Surprisingly, a leak can admit a fair amount of air without making noticeable exhaust noise.

isn't technically a vacuum leak—it's a metered air leak. If extra air slips past the throttle body without being accounted for by the computer, you're running lean.

Leaks are not just a problem for the Saturday mechanic. According to Zachary Parker, president of Redline Detection, which makes the Smoke Pro leak-detection system, "modern cars use engine vacuum to control an amazing number of things, and diagnosing leaks is a major issue for service technicians." Parker urges them to use his company's smoke machines on every car they service: "A large proportion of them have minor, otherwise undetected vacuum leaks," he says. Of course Parker is in the business of selling leak-detection equipment, but don't feel bad if you get stumped and have to seek professional service.

Hands-On

Any vacuum-leak safari should start out with one important tool in hand: a vacuum-hose diagram. It might actually be placarded in the engine bay. If not, look one up in the service manual or consult an online service such as AllData. Don't haphazardly spray carb cleaner on the lines (see "The Carb-Cleaner Trick").

Armed with the right information, check that both ends of every vacuum line are accounted for. I photocopy the diagram and use a highlighter to verify that I've inspected each one. Is every line attached to the right fitting at both ends? Is it still supple enough to bend as needed to grip its attendant spud? Is the plastic fitting okay?

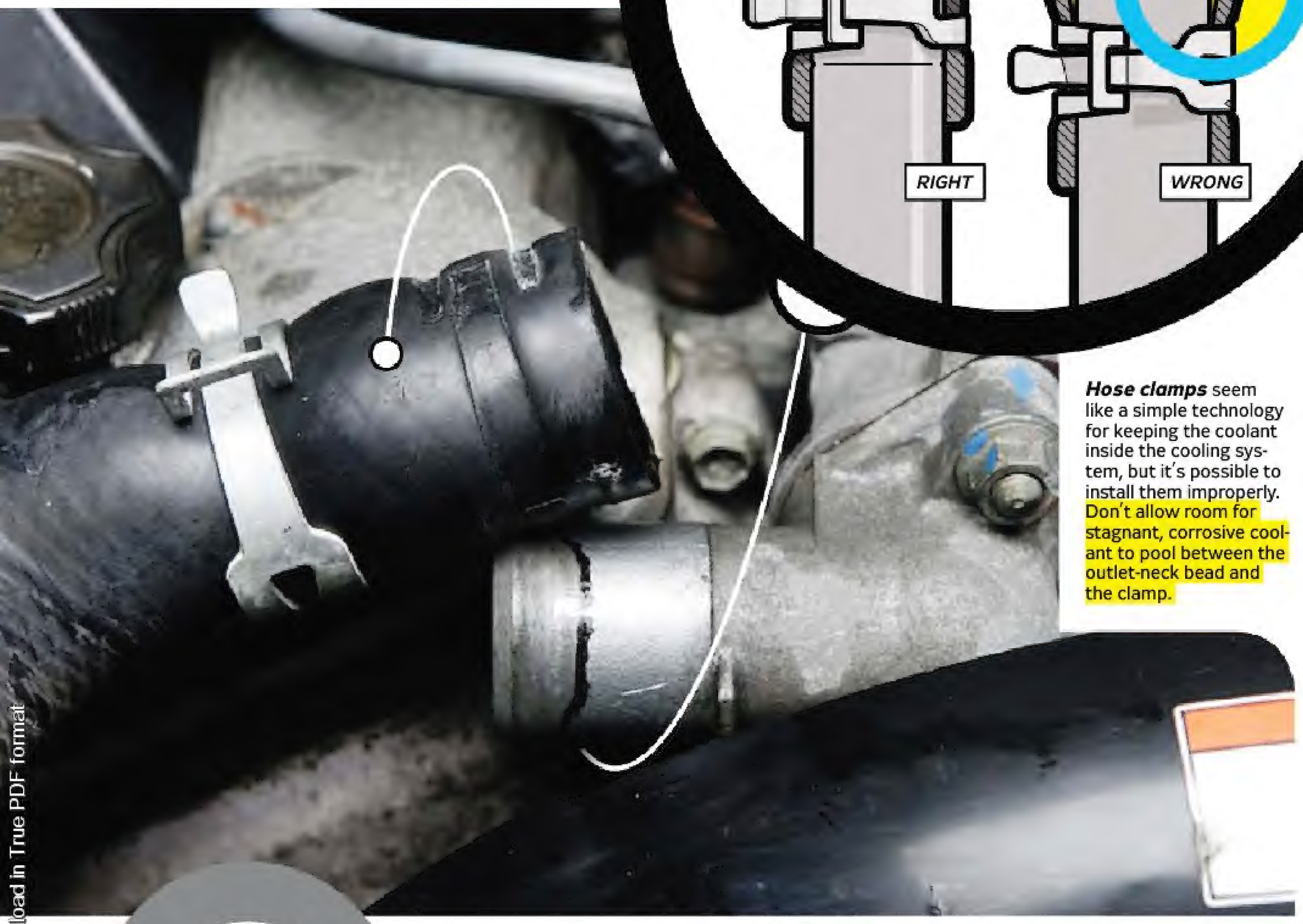
When I get an older car that shows signs of vacuum leaks, sometimes I systematically replace all of the vacuum lines individually. Ten feet or so of rubber line in a couple of sizes can be replaced—one line at a time, so you don't lose your place—in a half-hour or so. A half-dozen leaks so small they wouldn't be traceable can add up to one major leak.

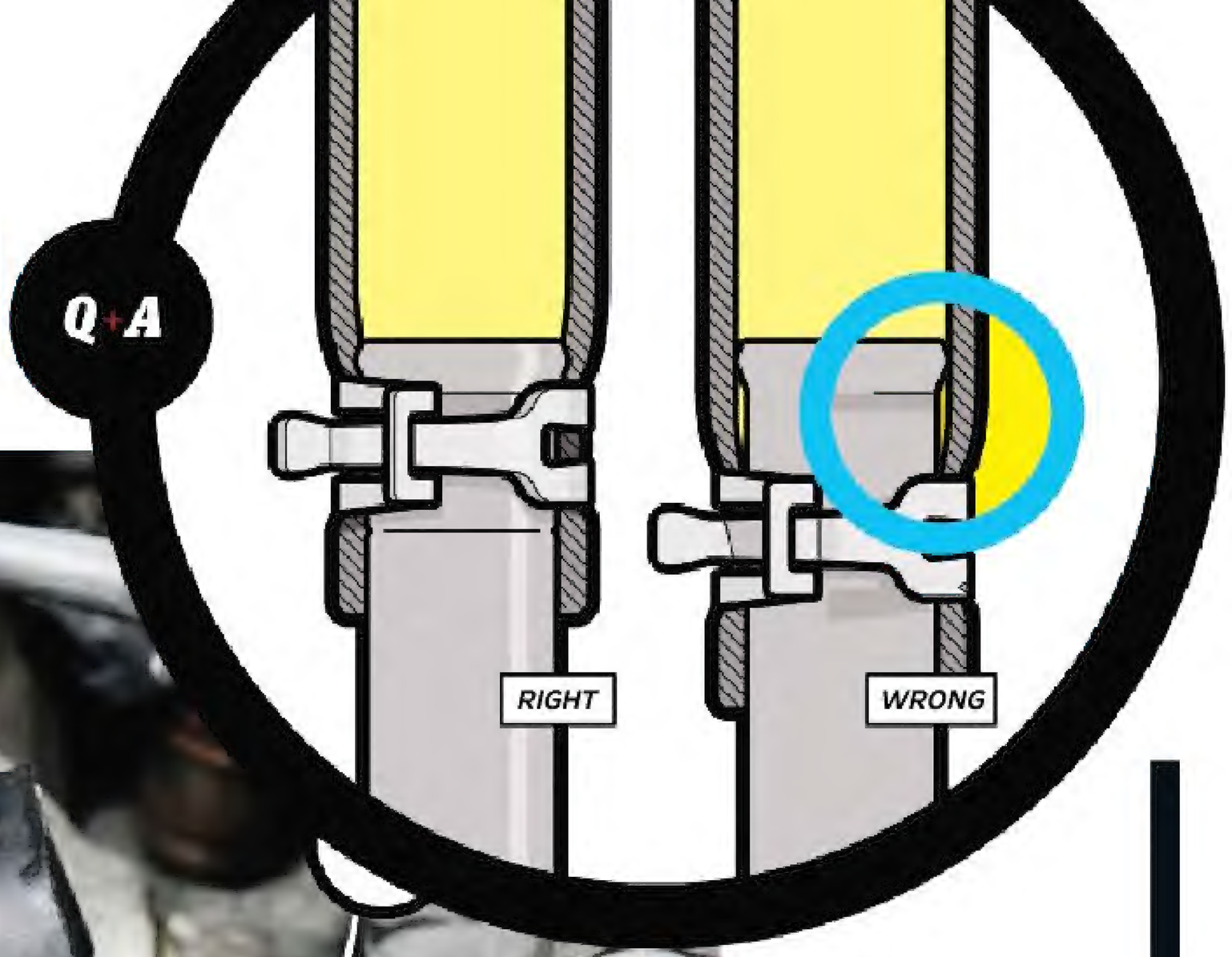
The Professional Method

Redline's Smoke Pro is a little bit pricey for a Saturday mechanic, starting at $750. (Comparable machines are more pricey and much bigger.) Pushing the smoke button gives you 5 minutes of thick white smoke—it's actually vaporized mineral oil, which you can buy at the drugstore—that gets pumped into the intake system and vacuum lines. The machine runs off the car's battery and uses shop air for pressure. An internal regulator keeps the pressure the Smoke Pro produces at levels low enough that it won't bust anything on the car but high enough so the leaks emit telltale puffs of smoke. Gotcha! With this system, we found a couple of leaks in an intake manifold in 5 minutes, even though we had no idea where to start. It's also good for finding exhaust leaks—an exhaust leak upstream of the O_2 sensor can pull in extra oxygen and mimic a vacuum leak, even if it's not large enough to make any noise. And the smoke, while not exactly pleasant, is a lot less tear-inducing, and much safer, than carb cleaner. **PM**

Car Clinic

by Mike Allen





Hose clamps seem like a simple technology for keeping the coolant inside the cooling system, but it's possible to install them improperly. Don't allow room for stagnant, corrosive coolant to pool between the outlet-neck bead and the clamp.

Hosed

I went to replace a spongy upper radiator hose on my antique car, and when I pulled off the old hose, half of the radiator neck came with it. It had corroded through the brass in a perfect ring around the neck, near the flared end. I put the hose back on the short remaining stub, and now it keeps blowing off as soon as the car heats up. What are my options? Do I need a new radiator, which is probably impossible to find? And why did this happen? The rest of the radiator looks fine, even the inside.

A This was due to the local failure of the coolant's anticorrosion additives in the small quantity of coolant trapped between the hose and the brass filler neck. It's caused by sloppy positioning of the hose clamp too far from the rolled bead in the neck. This allows stagnant coolant to collect in the cavity. Eventually, atmospheric oxygen works its way in, consumes the anticorrosion additives in the teaspoonful of coolant and corrodes its way through the metal.

Take your radiator to any decent radiator shop. They should be able to solder on a new neck to replace the corroded one fairly inexpensively. In fact, it would be a good idea to have them assess the state of the entire radiator. It might be wise to have the radiator shop remove both end tanks and rod out the tubes as well—we've already established that you've been

PHOTOGRAPH BY **DENNIS KLEIMAN**

ILLUSTRATION BY MERCÈ IGLESIAS

HARBOR FREIGHT TOOLS

Quality Tools at Ridiculously Low Prices

FACTORY DIRECT TO YOU!

How does Harbor Freight Tools sell high quality tools at such ridiculously low prices? We buy direct from the factories who also supply the major brands and sell direct to you. It's just that simple! Come see for yourself at one of our 330 STORES NATIONWIDE and use this 20% OFF Coupon on any of our 7,000 products. We stock Automotive products, Shop Equipment, Hand Tools, Tarps, Compressors, Air & Power Tools, Material Handling, Woodworking Tools, Welders, Tool Boxes, Outdoor Equipment, Generators, and much more.

NOBODY BEATS OUR QUALITY, SERVICE AND PRICE!

- √ We Have 10 Million Satisfied Customers
- √ We Buy Factory Direct and Pass the SAVINGS on to YOU!
- √ Shop & Compare Our Quality Brands Against Other National Brands
- √ Thousands of People Switch to Harbor Freight Tools Every Day!
- √ NO HASSLE RETURN POLICY √ Family Owned & Operated

LIFETIME WARRANTY ON ALL HAND TOOLS!

We Will Beat Any Competitor's Price Within 1 Year Of Purchase!

Get More Coupons at HarborFreight.com

SUPER COUPON!

20% OFF ANY SINGLE ITEM!

HARBOR FREIGHT TOOLS - LIMIT 1. Use this coupon to save 20% on any one single item purchased when you shop at a Harbor Freight Tools store. Cannot be used with any other discount or coupon. Coupon not valid on any of the following: prior purchases, gift cards, Inside Track Club membership, extended service plans, Compressors, Generators, Tool Cabinets, Welders, Floor Jacks, Campbell Hausfeld products, open box items, Parking Lot Sale items, Blowout Sale items, Day After Thanksgiving Sale items, Tent Sale items, 800 number orders, or online orders. Coupon cannot be bought, sold, or transferred. Original coupon must be presented in-store in order to receive this offer. Valid through 4/14/11. Limit one coupon per customer and one coupon per day.

77738318

SUPER COUPON!

US★GENERAL

SAVE $160

11 DRAWER ROLLER CABINET

LOT NO. 67421

INCLUDES:
- 6 Drawer Top Chest
- 2 Drawer Middle Section
- 3 Drawer Roller Cabinet

$139.99

REG. PRICE $299.99

HARBOR FREIGHT TOOLS - LIMIT 1
This valuable coupon is good anywhere you shop Harbor Freight Tools (retail stores, online, or 800 number). Cannot be used with any other discount or coupon. Coupon not valid on prior purchases. Coupon cannot be bought, sold, or transferred. Original coupon must be presented in-store, or with your order form, or entered online in order to receive the coupon discount. Valid through 4/14/11. Limit one coupon per customer and one coupon per day.

SUPER COUPON!

CENTRALPNEUMATIC

2 HP, 8 GALLON, 115 PSI PORTABLE AIR COMPRESSOR

LOT NO. 95386/67501/40400

$89.99 REG. PRICE $139.99

SAVE $50

Item 95386 shown

HARBOR FREIGHT TOOLS - LIMIT 1
This valuable coupon is good anywhere you shop Harbor Freight Tools (retail stores, online, or 800 number). Cannot be used with any other discount or coupon. Coupon not valid on prior purchases. Coupon cannot be bought, sold, or transferred. Original coupon must be presented in-store, or with your order form, or entered online in order to receive the coupon discount. Valid through 4/14/11. Limit one coupon per customer and one coupon per day.

SUPER COUPON!

3000 LB. CAPACITY LIGHTWEIGHT ALUMINUM RACING JACK

LOT NO. 91039/67408

U.S.GENERAL

$59.99 REG. PRICE $99.99

SAVE $40

Item 91039 shown

HARBOR FREIGHT TOOLS - LIMIT 1
This valuable coupon is good anywhere you shop Harbor Freight Tools (retail stores, online, or 800 number). Cannot be used with any other discount or coupon. Coupon not valid on prior purchases. Coupon cannot be bought, sold, or transferred. Original coupon must be presented in-store, or with your order form, or entered online in order to receive the coupon discount. Valid through 4/14/11. Limit one coupon per customer and one coupon per day.

SUPER COUPON!

OSCILLATING MULTIFUNCTION POWER TOOL

LOT NO. 67256

$29.99 REG. PRICE $59.99

CHICAGO Electric Power Tools

17 DIFFERENT ATTACHMENTS AVAILABLE IN OUR STORES!

SAVE 50%

HARBOR FREIGHT TOOLS - LIMIT 1
This valuable coupon is good anywhere you shop Harbor Freight Tools (retail stores, online, or 800 number). Cannot be used with any other discount or coupon. Coupon not valid on prior purchases. Coupon cannot be bought, sold, or transferred. Original coupon must be presented in-store, or with your order form, or entered online in order to receive the coupon discount. Valid through 4/14/11. Limit one coupon per customer and one coupon per day.

SUPER COUPON!

6" DIGITAL CALIPER

CEN-TECH

Item 47257 shown

SAVE 66%

LOT NO. 47257/98563

Includes two 1.5V button cell batteries.

$9.99 REG. PRICE $29.99

HARBOR FREIGHT TOOLS - LIMIT 1
This valuable coupon is good anywhere you shop Harbor Freight Tools (retail stores, online, or 800 number). Cannot be used with any other discount or coupon. Coupon not valid on prior purchases. Coupon cannot be bought, sold, or transferred. Original coupon must be presented in-store, or with your order form, or entered online in order to receive the coupon discount. Valid through 4/14/11. Limit one coupon per customer and one coupon per day.

SUPER COUPON!

18 GAUGE COMBINATION NAILER/STAPLER KIT

LOT NO. 97525/40115

CENTRAL PNEUMATIC CONTRACTOR SERIES

WE CARRY A FULL LINE OF FASTENERS!

$14.99 REG. PRICE $34.99

SAVE 57%

Item 97525 shown

HARBOR FREIGHT TOOLS - LIMIT 1
This valuable coupon is good anywhere you shop Harbor Freight Tools (retail stores, online, or 800 number). Cannot be used with any other discount or coupon. Coupon not valid on prior purchases. Coupon cannot be bought, sold, or transferred. Original coupon must be presented in-store, or with your order form, or entered online in order to receive the coupon discount. Valid through 4/14/11. Limit one coupon per customer and one coupon per day.

SUPER COUPON!

PITTSBURGH

6 PIECE PLIERS SET

LOT NO. 38082/46005

Item 38082 shown

$7.99

SAVE 46%

REG. PRICE $14.99

HARBOR FREIGHT TOOLS - LIMIT 1
This valuable coupon is good anywhere you shop Harbor Freight Tools (retail stores, online, or 800 number). Cannot be used with any other discount or coupon. Coupon not valid on prior purchases. Coupon cannot be bought, sold, or transferred. Original coupon must be presented in-store, or with your order form, or entered online in order to receive the coupon discount. Valid through 4/14/11. Limit one coupon per customer and one coupon per day.

SUPER COUPON!

1500 WATT DUAL TEMPERATURE HEAT GUN (572°/1112°)

LOT NO. 96289

SAVE 60%

$7.99 REG. PRICE $19.99

DRILL MASTER

HARBOR FREIGHT TOOLS - LIMIT 1
This valuable coupon is good anywhere you shop Harbor Freight Tools (retail stores, online, or 800 number). Cannot be used with any other discount or coupon. Coupon not valid on prior purchases. Coupon cannot be bought, sold, or transferred. Original coupon must be presented in-store, or with your order form, or entered online in order to receive the coupon discount. Valid through 4/14/11. Limit one coupon per customer and one coupon per day.

3 EASY WAYS TO SHOP!

1. VISIT! 330 Stores Nationwide
2. GO TO! www.Harborfreight.com
3. CALL! 1-800-423-2567

behind the curve in keeping the coolant fresh enough to prevent corrosion.

When you reinstall the new hose on the new neck, snug the hose clamp up close to the bead, so that there isn't any cavity for used-up coolant to hide inside.

Making Oil

I own an old pickup with a V6 engine. It currently has 112,254 miles on it. The Ranger takes about 4¾ to 5 quarts of oil. When I changed the oil, I noticed that almost 6 quarts came out and it smelled a little like gas. I always check the oil level on a level surface. I checked the antifreeze, but I am not losing any or gaining any. I was thinking that it is fuel that's getting into the oil, but I took the truck to another mechanic and he checked the fuel pressure and it was fine. Also, I am getting the same gas mileage. The Check Engine light is not coming on at all. What could be the problem?

You could confirm this by doing some oil analysis at a lab, but it's pretty obvious that you have fuel dilution. Somehow, raw, unburned gasoline is getting past the rings into the oil sump—even though the fuel pressure is fine. Actually, the fuel pressure has nothing to do with it. If your Check Engine light isn't on, there's no consistent misfire, so I'd suspect an injector that's got a coked-up pintle valve spraying raw, unatomized fuel onto the cylinder wall. Another possibility is an injector that's leaking raw fuel into the engine after shutoff.

Normally, modest amounts of unburned and partially burned gasoline will collect in the crankcase, especially during winter short-trip driving, when the oil rarely gets hot enough for long enough. Any raw fuel or moisture in the crankcase then starts to evaporate off once the engine gets up to normal operating temp and is then driven for an hour or two. Obviously, you aren't achieving this: Either there's an abnormal amount of raw fuel entering the crankcase, or you're not keeping the oil warm long enough to boil it off.

I have several suggestions: Check the positive crankcase ventilation (PCV) valve system for normal operation—be sure you're using the correct PCV valve, because some aftermarket suppliers will sell you a valve that's "pretty close" to the correct flow but isn't. It used to be that all you needed to do to check the PCV valve was put your thumb over the end of the PCV breather hose while the engine was idling to confirm vacuum. Today, with crankcase vent systems more artfully integrated into the manifold, that may not be possible. Check the factory service manual for specifics.

Be sure the thermostat is operating properly, be sure the cooling system and the oil are warming up properly, and then be sure to regularly drive it long enough to permit the PCV system to suck the gas fumes out. Idling in the driveway won't do it because the oil will never get sufficiently hot; you need to drive the vehicle long enough to heat the oil to its normal temperature and then keep it there 30 minutes or so. Also, try adding some fuel-injection-cleaner additive to your next three tankfuls. If that doesn't help within a few hundred miles, then it's time to get the injectors cleaned by a mechanic with the proper machine.

Don't ignore this. Eventually all that raw gas will wash the oil off the cylinder walls and score the rings.

Mixed-Up Impala

I have a 2008 Chevy Impala. I just recently had four new tires installed. The tire-monitoring system keeps telling me that the right rear tire is underinflated to 27 psi. I have checked the tire with my tire gauge and it has 38 psi, which is actually too high.

I'm going to go out on a limb and suggest that the shop that changed the tires didn't mark the rims to make certain they went back on the same corner. Usually, when those tire-pressure-monitoring-system senders go bad, they don't make mistakes and report the wrong pressure. Rather, they just quit. I'll bet lunch that one of your other three tires has that 27 psi in it. If they took your old RR tire and installed it on the LR, the car doesn't have any way to know that unless you tell it.

Have the shop check that the rims are installed on the correct corners of the car. And reprogramming the tire-

TOOL OF THE MONTH

HEX KEY

Sometimes a simple redesign of a classic tool can transform it. We've all used the awkward Swiss-Army-Knife-Allen-hex-wrench sets, and we've all hated them. Individual Allen wrenches? Worthy only of disposal after assembling the Ikea bookcase they came with. Our favorite, almost sensual, tool for hex-head hardware is Gear-Wrench's Flex Hex keys. The fit and finish are so much better than a standard 90-degree hex key, and the longer arm makes it easier to spin out a tight bolt at any angle. These babies have relegated my old hex-key multiwrench to the trunk of a car I sold to someone I didn't like. Around $30. *gearwrench.com*

PHOTOGRAPH BY MARC ASNIN

pressure-monitoring-system computer to recognize the wheels correctly is covered in the owner's manual. In fact, make the shop that sold you the tires do this, because they should have done it the first time. And you might also ask them to set the pressures to the correct 30 psi, not 38.

No User-Serviceable Parts Inside

I have a 1997 Saturn SC1, and no one can turn off the service light—not the Service Engine Soon light, it's just the service light.

That's the Maintenance Required light you're talking about, and it's just a simple, odometer-triggered reminder to change the oil. I'm glad you haven't confused it with the Service Engine Soon light (which most other car manufacturers refer to as the Check Engine light), which signals when something is amiss and needs the more or less immediate attention of a mechanic. On your particular Saturn, the procedure to extinguish this light is simple: In the fuse block under the hood, there is a little red button. Turn on the key (but don't start the engine) and then hold down the little red button for 5 seconds. The maintenance light should now be flashing. This confirms that the oil-life monitor has been reset.

Warning: This procedure is valid for only some years of some Saturn models. Other vehicles have wildly different procedures, from holding down a button while cycling the ignition to pressing two or more unrelated buttons on the dash while whistling Beethoven's Fifth. Late-model Hondas have an innocuous slot in the instrument panel that you can insert the ignition key into. You might be able to look up the correct procedure in your owner's manual. The dealership will probably tell you that you have to bring the vehicle in so they can reset it—which will likely cost you money. A little judicious searching on the Internet will turn up the procedure specific to your vehicle. And a few vehicles, notably some BMWs, will require you to use an expensive factory tool or scan tool (see above discussion about the dealer charging you).

My suggestion, if the whole procedure is too obscure or difficult, is to take the vehicle to some oil-change emporium or independent garage for an oil change and have *them* reset it, which ought to be included in the price of the oil-and-filter change.

Under Pressure

Several months ago, when I was returning home, my oil-pressure gauge became erratic and started to bounce all over the place. I was certain there was no problem with the actual oil pressure in the engine, just with the way it was reported, so I deduced that I needed a new oil-pressure transmitter, which I bought and installed. Now the needle of the dash gauge goes off the top of the 0-to-80-psi scale, perhaps to 120. When I turn the key off, the pressure drops to 40, and when I restart the engine, the pressure immediately drops to zero and then off the scale as the pressure builds up. I asked my mechanic about this condition, but he had absolutely no idea what might be the cause. Although I am certain the pressure is normal and have driven many miles with no problems since replacing the transmitter, I would appreciate your comments.

The original sender was bad, as you surmised. Verify this by temporarily hooking up a mechanical gauge, bypassing the electrical one. I usually do this by just duct-taping the gauge to the outside of the windshield and running the gauge's hydraulic line out of the cowl vents. Generally, I would do this before installing any new parts, regardless of what I might deduce from the way the car is working.

The second electrical sender is probably working as designed, but it's the wrong one, and it has the incorrect internal variable resistor to match up to your gauge face. Replace this sender with the correct part. **PM**

Got a car problem?
Ask **Mike** about it. Send your questions to ***pmautoclinic@hearst.com*** or over Twitter at ***twitter.com/PopMechAuto*** or to Car Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we cannot answer questions individually, problems of general interest will be discussed in the column.

Memory for Life

Performing at the speed of life.

Samsung PC Memory.

That's the Wonder of Samsung.

Whether it's a top-priority presentation or the highest level on your favorite game, now you can be equipped for maximum performance. Instantly. Efficiently. Samsung DDR3 PC Memory arms you with 40nm technology for optimum speed, yet uses a stunning 47 percent less power.* Because when life moves this fast, so should you. Another way Samsung is Dedicated to Wonder.

SAMSUNG

samsung.com/memory

*Max savings compared to conventional DDR3 using 60nm technology.

diy **Tech**

The Monitor Multiplex

ADDING EXTRA SCREENS TO YOUR COMPUTER IS AN EASY UPGRADE THAT CAN GET MORE WORK (AND PLAY) OUT OF YOUR PC. *BY GLENN DERENE*

For better or worse, it is a multitasking world we live in. And multiple monitors are uniquely useful for keeping track of numerous programs running simultaneously on your computer. Plenty of studies have pegged the productivity gained by adopting multiple monitors at anywhere from 9 to 50 percent (even if productivity for you means blasting opponents in *StarCraft II* while tweeting to

When your monitor count gets high, a well-designed mount can keep things organized.

PHOTOGRAPH BY **DAN SAELINGER**

your followers about how you totally pwned the Zerg). "Multiple monitors reduce [human] memory load by keeping more of your work in front of you," says Cornell professor of ergonomics Alan Hedge, "so you don't have to expend as much energy remembering where things are." According to Hedge, multiple screens can also make us faster, saving us from the task of constantly searching through files and folders for information. "It's like having a book with larger pages," he says. "You don't have to turn the page as often, since you can fit more information on each page."

The analogy of a computer desktop to a physical one is apt, and, in my experience, as the size of my home office desk has increased, the screens on it have gotten bigger and more numerous. I now have two 24-inch screens—one for always-on background applications such as e-mail, widgets and instant messaging, and another for whatever program I'm currently focusing on. And I am hardly an example of egregious excess; day traders routinely use three, four or even six screens simultaneously to watch their investments evaporate.

Monitor Math

Setting up multiple monitors isn't particularly difficult, but depending on the type of computer you have and how many screens you want, the complexity can ramp up quickly and require all sorts of cards, adapters and dongles. It's best to buy monitors that match the video outputs of your computer (see "What Video Plug Do You Need?"), but if your computer and monitor require different plugs, you'll have to choose from a constellation of adapters that provide a bridge between standards. Additionally, there are miniaturized versions of many of these connectors—Apple is particularly fond of integrating mini video ports into its laptops—which can require adapters just to mate them to their larger siblings (e.g., Mini DisplayPort to DisplayPort).

So how many monitors can you plug into your computer? That largely depends on your graphics card. Most graphics cards can support two monitors—for desktops, that typically means two independent screens can plug into the back of the PC. For laptops, the card can drive both the integrated display and one outside monitor. Some desktop computers allow you to add a second graphics card, which means you can connect four monitors. And there are gaming-enthusiast computers that support up to three graphics cards for a total of six monitor outputs—but at a couple hundred dollars per card and per screen, that can quickly get expensive.

Some higher-end graphics cards from AMD's ATI division use a technology the company calls Eyefinity, which allows a single graphics card to support up to six monitors. Likewise, specialty manufacturer Matrox has cards that can support up to eight monitors.

Outside Help

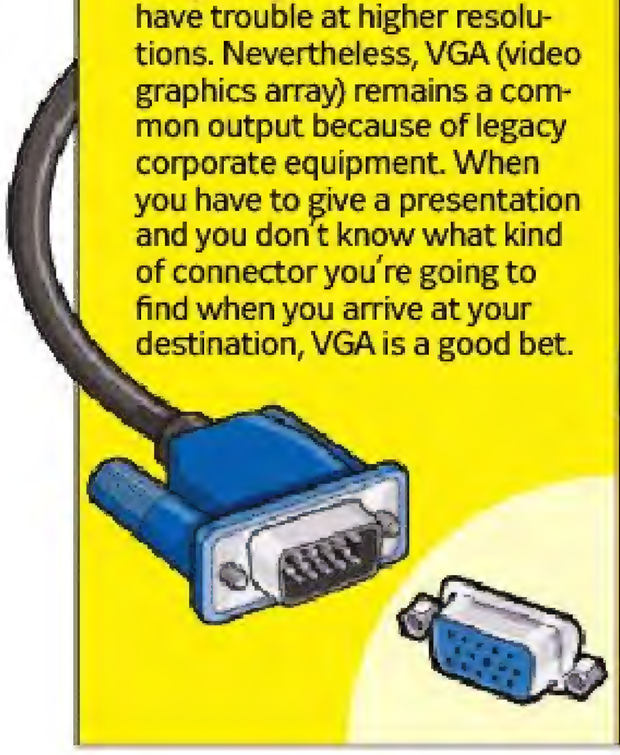
Some computers, however, can't take a second graphics card—smaller desktop machines don't have extra PCI Express slots available on their motherboards, and laptops are engineered without a millimeter to spare inside, so you're definitely not stuffing a big honkin' accessory like an extra graphics card in there. If you want to move beyond two monitors with these types of computers, you'll need an external adapter from a company such as Matrox or Accell. These devices either act as external graphics processors or trick your machine's internal graphics processor into thinking it's attached to one extraordinarily long monitor, which

WHAT VIDEO PLUG DO YOU NEED?

Before you run out and go screen shopping, it helps to know a few basics about connectors.

VGA

These analog connections carry image but no sound and have trouble at higher resolutions. Nevertheless, VGA (video graphics array) remains a common output because of legacy corporate equipment. When you have to give a presentation and you don't know what kind of connector you're going to find when you arrive at your destination, VGA is a good bet.

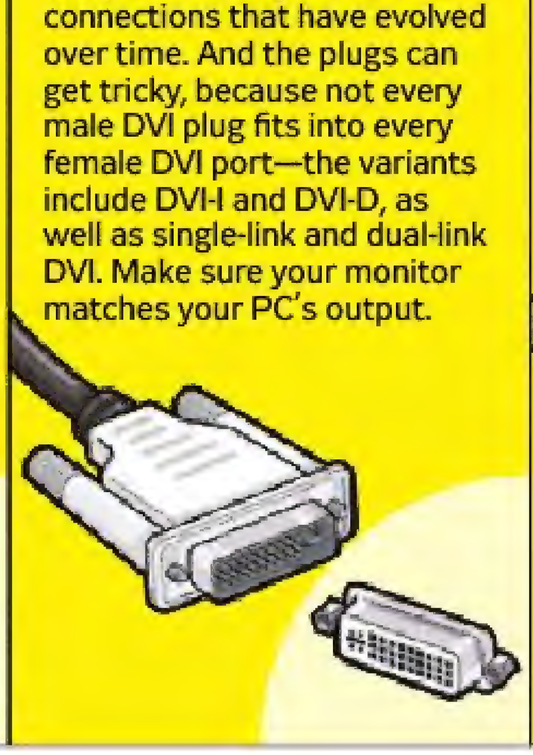


HDMI

The same hi-def connector that's found on many televisions is also working its way into computers and monitors. It supports high-definition video as well as multi-channel audio. Plus, computers with HDMI (high-definition multimedia interface) can—obviously—plug right into a big-screen HDTV.

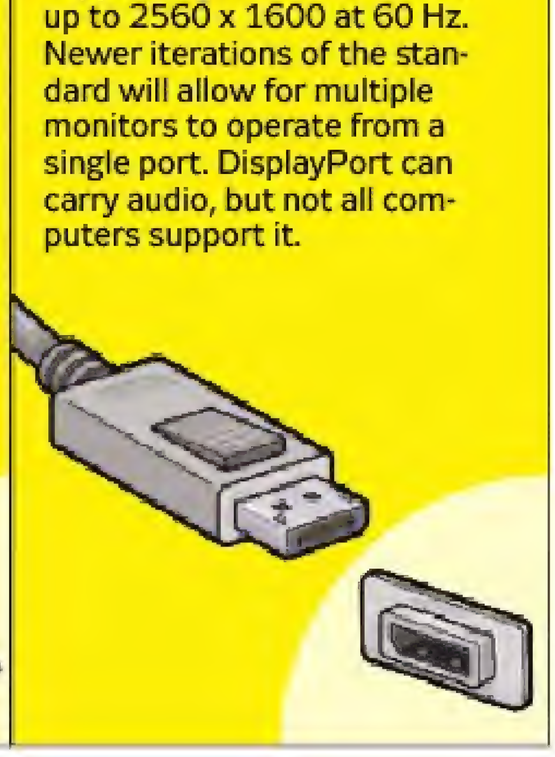
DVI

Short for digital visual interface, DVI is really a series of connections that have evolved over time. And the plugs can get tricky, because not every male DVI plug fits into every female DVI port—the variants include DVI-I and DVI-D, as well as single-link and dual-link DVI. Make sure your monitor matches your PC's output.



DISPLAYPORT

This connector can currently support high-resolution video up to 2560 x 1600 at 60 Hz. Newer iterations of the standard will allow for multiple monitors to operate from a single port. DisplayPort can carry audio, but not all computers support it.



ILLUSTRATIONS BY MERCÈ IGLESIAS

the adapter's software then chops up into individual screen "segments."

One final way to pull off a multimonitor setup is to use equipment compatible with the DisplayLink standard. DisplayLink gear sends a second-monitor video stream over USB or wireless USB. The video is then picked up on the other end by a television or monitor with a built-in graphics processor or any other video screen plugged into a dongle that does the processing itself. It's a nifty trick, but it requires quite a bit of compression and uses low-end processors to render the video—which, in my experience, works well with static screens but can murder the quality of a good video stream.

The Art of Arrangement

Regardless of how you attach your extra screens, you're still going to have to do a bit of software tinkering after you've plugged them into your computer. Modern operating systems such as Microsoft's Windows 7 and Apple's OS X Snow Leopard have made setup much easier than it used to be, but all sorts of craziness can still go on when you plug in an extra display. Sometimes your monitor shows up, sometimes it doesn't. Both Windows and OS X have a way for users to force the computer to find any connected monitors—in Win 7, it's under the Control Panel category Change Screen Resolution; in Snow Leopard, it's a button called Detect Displays under the Displays submenu of System Preferences.

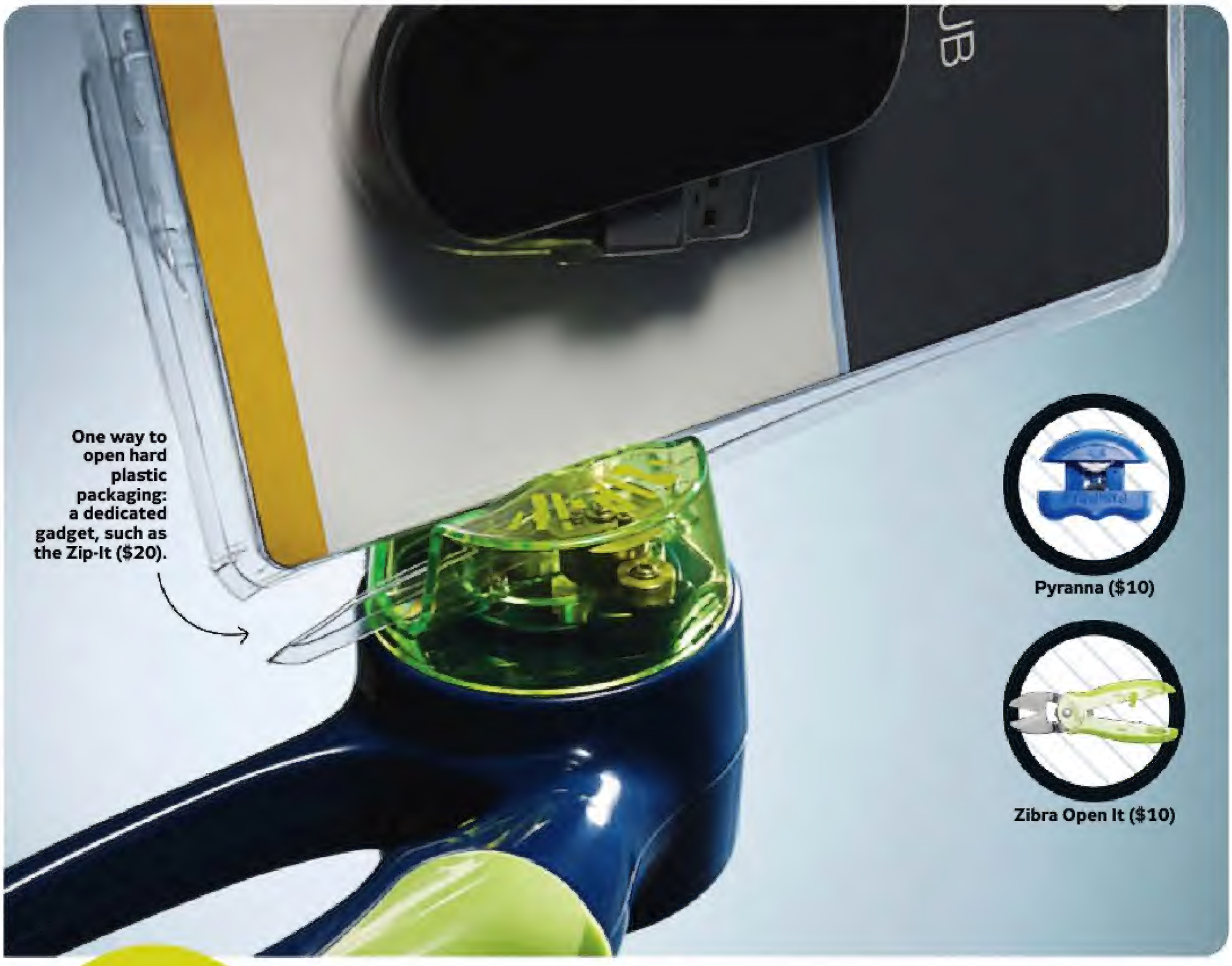
Once your computer has found the displays, it's up to you to orient them. Both OSs allow you to drag and drop each monitor to match how it is placed physically on your desktop. Digital connections through DVI, HDMI and DisplayPort should automatically detect the resolution of your new monitor, but connections through an analog VGA cable may require you to set the resolution manually. For best performance, you generally want to set to the highest resolution possible on your monitor—and, unless you have a reason to do it differently, keep the refresh rate set to 60 Hz, which is the standard for U.S. monitors and TVs. Finally, both OSs allow you to designate a primary screen, where your taskbar and system tray will reside; any other screen will play second fiddle. In Windows, select the icon for your main screen in the Change Screen Resolution section of Control Panel, then check off the "Make this my primary monitor" box. In OS X, under the Displays submenu in System Preferences, you'll see that one of the screen icons will have a white bar across the top. Grab that bar and drag it to the monitor you want as your main display. Ergonomics expert Hedge suggests setting up your main monitor to match your dominant eye. (Righties will probably want to make the right monitor the main one. Lefties? Vice versa). Use your screens to keep organized—dedicate individual programs to primary or secondary screens based on importance.

So how do you determine if your extra monitors have made you more productive? I'm no academic, but I propose this simple experiment to assess the value of a multiscreen setup in your home: After you've installed an extra monitor, use it for a few weeks, then take it away. Miss the extra real estate? I figured you would. **PM**

Digital Clinic

by Seth Porges

Q+A



One way to open hard plastic packaging: a dedicated gadget, such as the Zip-It ($20).

Pyranna ($10)

Zibra Open It ($10)

Taking the Edge Off Wrap Rage

A lot of my gadgets seem to come in impossible-to-open plastic packages. Using a knife to unwrap them seems dangerous. Any suggestions on a better way to pry them open?

A For all the advances electronics companies have made in creating simple, intuitive user interfaces, the packaging often seems to be stuck in a prehistoric stone or, more accurately, plastic age. These nearly impenetrable shells, which are often called oyster, clamshell or blister packs, are ubiquitous precisely because they are hard to open—the inconvenience is designed as a defense against shoplifting. Store security staffs may love them, but clamshells are reviled by everyone else—the term "wrap rage" has been coined to describe customer frustration. There's even a safety issue: The Consumer Product Safety Commission estimates that more than 6000 people each year end up in the emergency room due to injuries sustained while opening packages. The

PHOTOGRAPHS BY **DAN SAELINGER**

true number of injuries is probably higher—not everybody goes to the ER for a sliced finger.

Now, where there's consumer irritation, there's a product category ready to spring up. And, just because you asked, I tested three devices designed to open blister packs.

First up was the Pyranna ($10)—a blister-pack-opening gizmo that came packaged in . . . a blister pack. Ironic, isn't it? And yes, this did prove to be an omen of bad product design to come. The plastic device feels a bit like a grip exerciser or a stress reliever—squeeze it and it brings a thin razor down into the offending plastic. However, it took multiple swipes of the tool to slice open most plastic packs, and the mechanism that locks the device in an open or closed position jammed repeatedly.

The Zip-It ($20), which looks and works a bit like an electric can opener, seemed more promising. The packaging boasts that the Zip-It is "the world's first battery-operated clamshell package opener." The little motor certainly helped—the Zip-It roared through most plastic packages with ease. And while the instructions warned that the tool could have problems with especially thick plastic packages, it handled with aplomb nearly any blister pack I could lay my hands on. However, the device may be a bit much: It's a fairly large single-purpose gadget, and, for me at least, it's simply not worth the drawer space.

Next up was the Zibra Open It ($10), a scissor-like slicer. I had decent luck with this device: It was adequately sharp and much easier to use than the Pyranna, though it lacked the horsepower of the battery-aided Zip-It. Unlike the other gadgets, the Open It isn't a one-purpose tool—the handle conceals a small utility knife and screwdriver.

So which tool would I recommend? While the Zip-It did the best job of opening packages, it really was no more effective than a good pair of shears. And with shears, no batteries are required. So I'm still looking forward to the day when manufacturers stop using these annoying packages, and the devices designed to open them turn into paperweights.

There is some hope on the horizon: Amazon has been putting pressure on manufacturers to create easier-to-open paper packages specifically for their customers. (Shoplifting isn't a concern for online retailers.) And companies that have gone along with this initiative—including Duracell, Philips and Procter & Gamble—have reported huge improvements in their Amazon customer ratings. So if the ER bills don't get companies to end their addiction to blister packs, maybe old-fashioned consumer feedback will.

Shattered Glass

I read online that the glass back on the iPhone 4 can shatter. Is this something I need to worry about?

Previous versions of the iPhone were made with plastic and metal backs. So it was with some surprise and excitement that the tech community greeted the iPhone 4's glass posterior. So smooth! So shiny! So pretty!

Alas, all that glitters is not the perfect material from which to build a phone. When you slide the iPhone 4 into a case, tiny particles of dirt, sand and grime can get stuck between the two surfaces. And, eventually, that can cause the glass to crack.

Apple's response has been quick, though covert. The company didn't acknowledge the problem publicly when it arose (and was still keeping mum at press time), but it did remove all third-party slide-on iPhone 4 cases from Apple Store shelves. For now, we'd stick to "bumper"-style cases that wrap only around the edges of the phone—because they don't cover the back, they don't cause the damage. Meanwhile, the website *gdgt.com* reported in the fall that Apple engineers were working hard to come up with a fix.

Double Speak

My Bluetooth headset is marketed as having two microphones. What possible advantage could this offer?

If you used a Bluetooth headset just a few years ago, you probably have bad memories of wind and background murmurs interfering with your conversations. That's why most newer headsets have a second mic built in. The extra mic scans for ambient noise, which the headset's internal processor then attempts to remove from the signal. (A similar technology has been used for years by noise-canceling headphones.) So does it work? For the most part, yes. While you won't be able to carry on a whispered conversation at Lollapalooza (it's not magic), the technology does a good job of eliminating modest levels of background noise.

Giving Discs the Boot

The hard drive on my MacBook is having problems, and I want to boot directly from an optical disc. How do I do this?

Easy. Just turn the computer off, then hold down the "C" key while you start it up again. If your hard drive is acting up, this allows you to boot directly from an OS X or third-party recovery disc, and maybe even saves you a trip to the Genius Bar. **PM**

Got a technology problem?
Ask **Seth** about it.
Send your questions to ***pmdigitalclinic@hearst.com*** or over Twitter at ***twitter.com/sethporges.*** While we cannot answer questions individually, problems of general interest will be discussed in the column.

Popular Mechanics (ISSN 0032-4558) is published monthly, 12 times a year, by Hearst Communications, Inc., 300 West 57th Street, New York, NY 10019, U.S.A. Frank A. Bennack, Jr., Vice Chairman and Chief Executive Officer; Catherine A. Bostron, Secretary; Ronald J. Doerfler, Senior Vice President, Finance and Administration. Hearst Magazines Division: Cathleen P. Black, Chairman; David Carey, President; John P. Loughlin, Executive Vice President and General Manager; John A. Rohan, Jr., Vice President and Group Controller.

Periodicals postage paid at N.Y., N.Y., and additional entry post offices. Canada Post International Publications mail product (Canadian distribution) sales agreement no. 40012499. CANADA BN NBR 10231 0943 RT. POSTMASTER: Send address changes to Popular Mechanics, P.O. Box 6000, Harlan, IA 51593. Printed in U.S.A.

EDITORIAL AND ADVERTISING OFFICES:
300 West 57th Street, New York, NY 10019-3797.

SUBSCRIPTION SERVICES:
Popular Mechanics will, upon receipt of a complete subscription order, undertake fulfillment of that order so as to provide the first copy for delivery by the Postal Service or alternate carrier within 4–6 weeks.
>>> Subscription prices: United States and possessions: $24.00 - for one year. Canada and all other countries: $40.00 - for one year.
>>> Should you have any problem with your subscription, please visit service.popularmechanics.com or write to Customer Service Department, Popular Mechanics, P.O. Box 6000, Harlan, IA 51593. Please enclose your mailing label when writing to us or renewing your subscription.
>>> Popular Mechanics is not responsible for unsolicited manuscripts or art. None will be returned unless accompanied by a self-addressed stamped envelope.

MAILING LISTS:
From time to time we make our subscriber list available to companies who sell goods and services by mail that we believe would interest our readers. If you would rather not receive such mailings, please send your current mailing label or exact copy to: Popular Mechanics, Mail Preference Service, P.O. Box 6000, Harlan, IA 51593.

AS A SERVICE TO READERS,
Popular Mechanics publishes newsworthy products, techniques and scientific and technological developments. Due to possible variance in the quality and condition of materials and workmanship, Popular Mechanics cannot assume responsibility for proper application of techniques or proper and safe functioning of manufactured products or reader-built projects resulting from information published in this magazine.

BUYER'S GUIDE

For advertising rates call Angela Hronopoulos (212) 649-2930, fax: (646) 280-2930.

CLASSIFIED ADS

To reach over 9 million prospects, or for additional advertising information, call Kathleen Gleason at **708-352-8304,** or e-mail: **klassmark@aol.com**.
Thank you for choosing Popular Mechanics Classified Advertising, 512 West Burlington Ave., LaGrange IL 60525.
For subscription questions, visit service.popularmechanics.com.

ALTERNATIVE TRANSPORTATION

Electric and Gas Powered Bicycles, Bike Conversion Kits, Scooters, Minibikes, Mopeds, Dirtbikes, ATVs, **WWW.FIVEFLAGSMOTORBIKES.COM**, (850) 941-2080.

ALTERNATIVE HEATING

COMBINATION WOOD WARM AIR FURNACES - STOVES SAVE $$$ ON YOUR HEATING BILLS FACTORY DIRECT CALL TODAY 1-800-358-0060 www.yukon-eagle.com

APPAREL

SUSPENDERS WITH PATENTED No-Slip Clip. Free Catalog 800-700-4515. **www.suspenders.com**

ARTS, CRAFTS, SUPPLIES

WHOLESALE PRICES ON JEWELRY CRAFT ITEMS, Beads & Beading Supplies, Rockhound Supplies, Belt Buckles, Clock Movements. Free 122 page catalog. **Eloxite**: Dept. 45, Box 729, Wheatland, WY 82201, **Ph.: 307-322-3050 Web: www.eloxite.com**

AUTOMOTIVE

AMSOIL, SYNTHETIC LUBRICANTS. Buy Direct, Register to Buy Wholesale. **Free Catalog.** 1-919-269-3331. **www.synthoils.com**

BICYCLES

GOLDEN EAGLE BICYCLE ENGINES 2 & 4 Cycle Geared Belt 25 - 40cc 517-410-2793 bikeengines.com

BOATS, OUTBOARDS, TRAILERS

BOAT KITS - PLANS - PATTERNS - SUPPLIES Catalog $5.00, Clarkcraft, 16-6 Aqualane, Tonawanda, NY 14150. 716-873-2640. www.clarkcraft.com

BUILD A BOAT - Using full size patterns, 7' to 55', send $9.95 for **NEW** Catalog and Free Plans. Glen-L, 9152 Rosecrans/PM. Bellflower, CA 90706. 888-700-5007. **WWW.GLENL.COM/OFFER9**

BUSINESS OPPORTUNITIES

Make $500 Weekly, E-Z Assembly work. FREE Information, Send SASE; JDK-P Box 635, Hopkins, MN 55343-0635

BUSINESS OPPORTUNITIES

CONCRETE CHARLIE™ SAYS: Claim your piece of the $100 Billion waterproofing industry and become a foundation crack repair specialist. Most Complete Training in the Industry! Don't Wait! Territories available NOW! Or, buy a kit and fix **your** cracks! **www.concretecharlie.com** Enter Pop. Mech Promo Code: 971208

$400 WEEKLY ASSEMBLING Electronic Circuit Boards/Products. Rush S.A.S.E.: Home Assembly - PM, P.O. Box 450, New Britain, CT 06050-0450

BECOME A HOME INSPECTOR! Make $50,000+ per year. Free information at **www.HomeInspectionBook.com**

DO-IT-YOURSELF

HYDRAULIC JACK REPAIR Manual and catalog: $15.00 620-594-2247, Hydraulic Parts Supply, P.O. BOX 97-PM, Sawyer, KS 67134.

DIY FLIGHT SIMULATOR MOTION RIDE! Use with computer simulation programs, video games. Easy PVC, hand tool project. Must see: **www.acesim.com**

FREE KNIFE MAKING CATALOG! Build your own knife. Complete kits available. Over 1200 products. Visit: **www.knifekits.com** or call 1-877-255-6433 today

FOOD

TODAY'S FARM® Freeze-dried Fruit Snacks Order now at **www.TodaysFarm.net** 10% Discount with Coupon Code: PM

FREE

SOON THE GOVERNMENT will enforce the **MARK OF THE BEAST** as **CHURCH AND STATE** unite! Let **THE BIBLE** identify him. **FREE BOOKS/DVDs** The Bible Says, P.O.B. 99, Lenoir City, TN 37771 thebiblesaystruth@yahoo.com **1-888-211-1715..**

ELECTRONICS

CONDUCTIVE PAINT, EPOXY From $12. Silver or carbon paint. Silver epoxy. Carbon tapes. Custom formulas available. www.semsupplies.com 301-975-9798 (M-F).

ELECTRONICS

Digital Copyguard Eliminator, Stabilize and Restore Distorted Video. Guaranteed to work with all DVD and VHS Systems. Free Information Package 574-233-3053. www.rcdst.com

PRINTED CIRCUIT BOARD DESIGN Schematic, Layout, Packaging, Fabrication and Assembly. Reverse Engineering Prototypes to Production Your one stop solution! **www.PCB3D.com**

ENGINES

Below **WHOLESALE PRICED SMALL ENGINES,** Briggs, Tecumseh, Kohler, Kawasaki, and others. Send $3.00 for Catalog: Thompsons Small Engine, 156 Anderson Drive, Brunswick, GA 31520.

FINANCIAL

RARE COIN INVESTMENTS. Our clients **DON'T LOSE** money! **FREE** brochure. **DENKO** 1-877-777-1754.

FOR INVENTORS

PATENT YOUR BRILLIANT INVENTION!!! Registered Patent Attorneys Available to Assist You New York and New Jersey Offices Call (646) 373-2504 or Email: **INFO@PATENTANDTAXLAW.COM**

PATENT ATTORNEY with 30 years high technology experience. Focus on U.S. and foreign patent prosecution. Free confidential consultation. johnwoolridge@comcast.net 925-292-4777.

HEALTH & FITNESS

WANT MORE JOY AND AN END TO CRAVINGS? CES can potentially triple your Endorphins and provide outstanding benefits to your health. 866-944-3113 **www.BestBrainMachines.com**

HEARING AIDS

FREE HEARING AID CATALOG. CUSTOM DIGITAL AND PROGRAMMABLE. HUGE SAVINGS. 45 DAY TRIAL. BETTER HEARING, PO BOX 219 DEPT 32, BROOKPORT, IL 62910. 1-800-320-3300 Ext. 32

HEARING AIDS

HEARING AIDS - GUARANTEED LOWEST PRICES!
No huge commissions.
Home trial, terms. All makes.
We're the oldest, biggest, best.
Custom instrument specialists.
Free information, 1-800-323-4212.
Lloyds-PMC

DIGITAL HEARING AID SALE
16 channel bands, any size, any type or BTE $33995
Options: touchtone, twin mics, custom molded - $50.00
New! Open Fit Technology - most brands - big discounts
Repairs $77.00 (since 1981)
Free brochure & mold kit
Hearing One 1-800-249-4163
100 Main Street, Marty SD 57361

GIVE THE GIFT OF HEARING
Improve your marriage/
Feel years younger.
Doctor - Designed MDHearingAide
$169.99 with coupon "PM"
Money Back Guarantee
Quantities limited - Call / Visit NOW!
www.MDHearingAid.com
888-670-HEAR (4327).

HELP WANTED

$400 WEEKLY ASSEMBLING
Electronic Circuit Boards/Products.
Rush S.A.S.E.:
Home Assembly - PM, P.O. Box 450,
New Britain, CT 06050-0450.

INVENTORS

INVENTORS: Free information tells how to offer your invention for sale or license.
Kessler Corporation, 52+ years
800-537-1133, ext. 25,
www.kesslercorp.com

PROTECT YOUR IDEA!
Write Your Own Patent Application
PatentPro® Software
www.patentpro.us

INVENTORS – NEVER SEND IDEAS TO STRANGERS!
LEARN AFFORDABLE PROTECTION / MARKETING METHOD
NON-PROFIT ORGANIZATION.
FREE INFORMATION: 1-800-846-3228. www.inventassist.com

JEWELRY

.....WITH MOTION IN MIND.....
KINEKT DESIGN GEAR RING:
Interactive jewelry for men & women.
Turn the outer rims of the ring & see the gears move (watch our video!).
Lifetime Warranty & Free Shipping.
Order online or call 1-888-600-8494.
www.kinektdesign.com

LAKES & PONDS

LAKE OR POND? Aeration - 1st Step towards improved water quality.
Complete Systems $169 - $329
11,000 Gal. Per Hour Water
Fall Pump only 3.6 amps! Just $399.95
www.fishpondaerator.com
608-254-2735 Ext. 3

LIVE STEAM MODELS

WORKING STEAM ENGINES
Discounts! Accessories, Parts,
Stirling Engines.
Limited Edition Tin Toys, Cars & Trains.
Catalog $6.95 Refundable.
Yesteryear Toys
Dept. PMS Box 537
Alexandria Bay, NY 13607
www.yesteryeartoys.com
1-800-481-1353.

METALWORKING

BUILD, REPAIR, RESTORE ANY METAL
Quality Hand-tools & Forming Machines for Automotive, Aviation,
Homeshop, Sculpture, Instructional DVDs & Workshops.
20 years & still the best!
Free catalog 530-292-3506
www.tinmantech.com

MUSICAL INSTRUMENTS

WE BUY GUITARS! Vintage City Guitars pays top dollar for any guitar, any condition! Fast Cash! Honest, reliable!
800-791-2734. www.buyguitartoday.com

OF INTEREST TO ALL

FREE CATALOG by mail. Meet nice singles, women, men. Photos. Profiles.
All ages. Since 1981.
Box 310, Allardt, TN 38504
Call 931-879-4625.

OF INTEREST TO MEN

SINGLE RUSSIAN LADIES
Seek romance, marriage.
E-mail, tours, free ads for men.
Anastasia Intl. Since 1994.
HTTP://WWW.ANASTASIADATE.COM

HOT LOCAL WOMEN
Listen to Ads & Reply..FREE!
FREE Code 7569, 18+
1-888-634-2628
www.MegaMates.com

ASIAN BRIDES! Worldwide!
Free Details/Photos!
PIC, Box 4601-PM, T.O., CA 91362.
805-492-8040. www.pacisl.com

SEXUAL AIDS

WORLD'S LARGEST SELECTION OF SEX TOYS
Erection Aids, Vibrators, Holiday Items,
Gag Gifts, Fetish Items.
www.ADULTNOVELTIESWAREHOUSE.COM

QUIT SMOKING

NO PILLS, NO WITHDRAWALS, NO FAKE CIGARETTES. Proven method.
Send: S.A.S.E. and $10.00 to:
Quit Smoking, 135 Adams Lane,
Bell Buckle, TN 37020.

SNOW GUARDS

STOP SNOW SLIDES ON METAL ROOFS!
Practically Invisible, Easy Installation,
Online Estimator.
Fast Shipping **www.snojax.com**

SOLAR ENERGY

SOLAR PANELS, regulators, from $50,
10 - 150 watts, high efficiency, by German equipments. Limited $time.
For camping, cabins, reverse the meter!
866-439-8004,
sales@solartorrent.com,
http://www.solartorrent.com

SONGWRITING

Your song or poem
MAY EARN YOU MONEY.
Send your material to:
NDM Studios, P.O.B. 123, Mastic, NY 11950

STEEL BUILDINGS

STEEL BUILDINGS, designed for the do it yourselfer. Buy direct from the factory & SAVE THOUSANDS.
Worldwide Steel Buildings
www.wsbnow 800-825-0316.

TOOLS

YOUR SCREWDRIVER - YOUR WAY!
PICQUIC MULTI-BIT SCREWDRIVERS
NOW AVAILABLE CUSTOM-LOADED.
CHOOSE FROM 60 BITS.
IMMEDIATE SHIPPING
CANADIAN, LIFETIME WARRANTY
FIREHAWKTECH.COM -
800-920-HAWK

TREASURE FINDERS

BURIED TREASURE – Sensitive equipment allows locating from distance.
Brochure free. Simmons, Box 10057-MA,
Wilmington, NC 28404
www.simmonsscientificproducts.com

WANTED TO BUY

BUYING GOLD, SILVER, PLATINUM - ANY FORM
60 years experience. Free pricing quotes.
Top payment. 1-800-932-1010
www.preciousmetalsreclaiming.com

WATER PURIFIERS

DRINKING WATER SCAMS EXPOSED!
Free Special Report ($15.00 Value)
Find out which water is best for you!
800-874-9028 waterwise.com

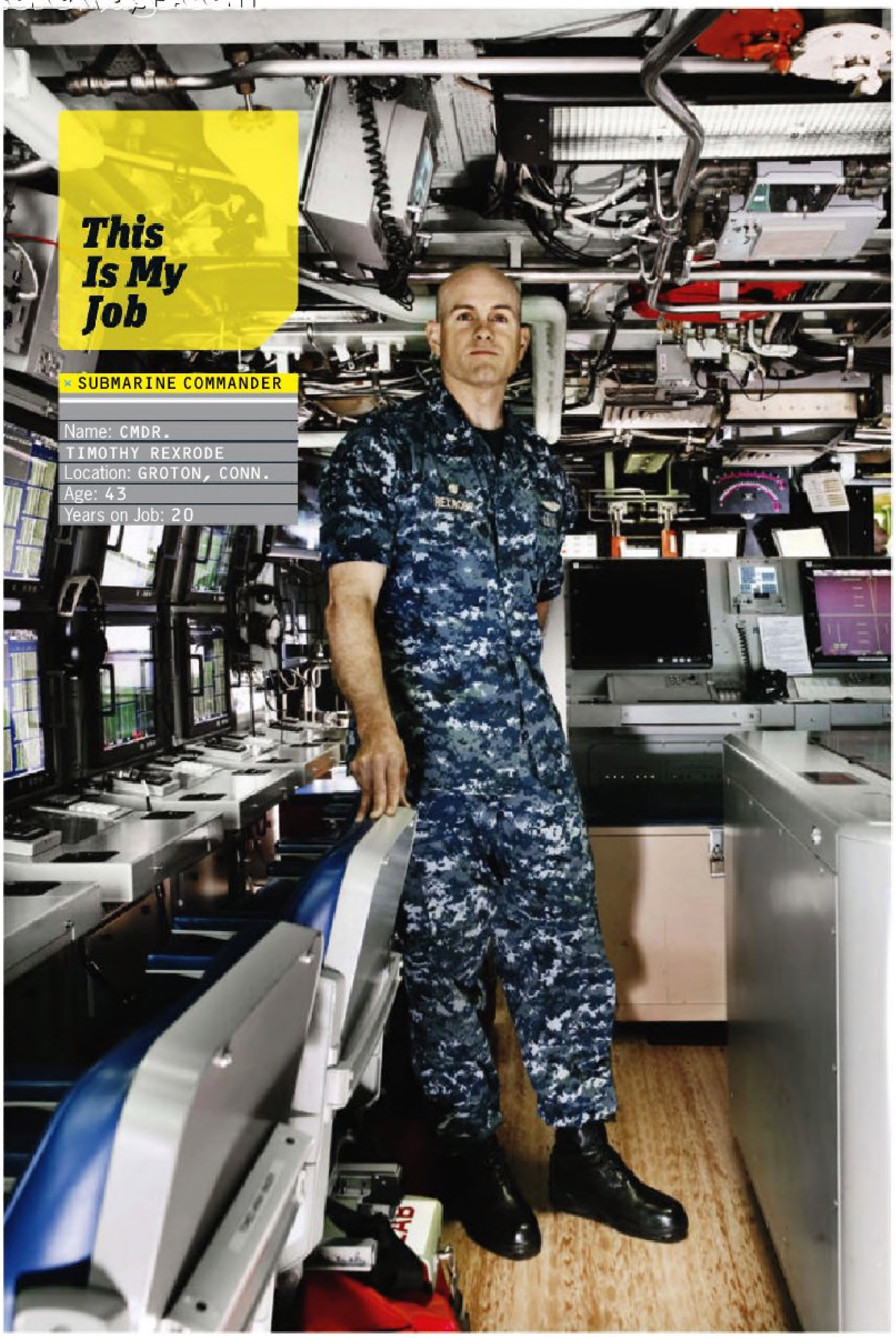
WINE/BEER MAKING

WINEMAKERS - BEERMAKERS.
Free Catalog. (800)841-7404. Kraus,
7850-L, Independence, Missouri 64054.
www.eckraus.com/offers/L.asp

This Is My Job

- SUBMARINE COMMANDER

Name: CMDR. TIMOTHY REXRODE
Location: GROTON, CONN.
Age: 43
Years on Job: 20



How do you drive a 7800-ton nuclear-powered submarine that's longer than a football field and capable of launching 16 Tomahawk cruise missiles? Very carefully, says commanding officer Timothy Rexrode, who served his first sea tour 20 years ago on a sub designed in the 1950s. Today, Rexrode is the captain of one of the most advanced ships in the Navy, the USS *Missouri* (SSN-780). The differences are striking. "We used to use paper, pencils and rulers" for navigation, Rexrode says. "Now we're all digital." These days, the captain can monitor the ship with the click of a mouse and watch a live view from the photonics mast on a screen in his stateroom. But when he's piloting the sub into port in dense fog, Rexrode still relies on his two decades of experience—not just technology—to guide him. "Half of it is instinct," he says. "It's pretty exhilarating." — *EMILY HAILE*

Anatomy of a Modern Submarine

PHOTONICS MASTS

The traditional optical periscopes with prisms have been replaced by two masts outfitted with hi-def cameras, infrared sensors and a laser rangefinder, all controlled by joystick. Hi-res digital images can be taken from as far as a mile away; they're routed to two flat-panel screens in the command center (shown at left), which has an open layout that puts sonar and combat systems in one fully networked room.

SONAR

The *Missouri* is blanketed in sonar sensors, including an array on its chin that is capable of mapping the ocean floor and detecting minefields. Additional sensors towed behind the ship eliminate blind spots. The sonar is primarily used to listen passively, but it can also transmit to satellites and communicate with internal weapons systems.

CAPTAIN'S TOOLS

To pilot the sub into and out of port, Rexrode stands on the conning tower and navigates using waterproof binoculars with compass bearings, which are sealed and filled with nitrogen gas to prevent fogging. He also carries a handheld GPS and a portable laser rangefinder to determine the ship's distance from the pier.

DIGITAL NAUTICAL CHARTS

In the past, sub crews plotted routes by hand, a laborious and time-consuming process. But the *Missouri* is equipped with a system that uses sensors and GPS to continuously update digital charts—and sounds an alarm if the sub veers off course or gets close to hazards. "I've seen lots of different ships with lots of different gear," Rexrode says. "This is the best."

PHOTOGRAPH BY **DOUG ADESKO**

SURGEON GENERAL'S WARNING: Cigarette Smoke Contains Carbon Monoxide.

CIGARETTES

REBUILT PACK. CLASSIC TASTE.

Commonwealth BRANDS INC
www.commonwealthbrands.com
An IMPERIAL TOBACCO GROUP company

USA GOLD

YOUR SPIRIT. YOUR SMOKE.

JOINUSAGOLD.COM

odyssey.honda.com

VAN. MYTH. LEGEND.

The best-selling minivan in the land is now vanlier than ever before. Available features like a Split-Widescreen Rear Entertainment System†, a hard drive that fits thousands of songs,** a USB Audio Interface†† and a leather-trimmed interior will have you riding in dazzling van glory. While a powerful and efficient 28 hwy mpg‡ V-6 engine will take you places you forgot existed. Introducing the all-new Honda Odyssey.* ***Like no van before.***

ODYSSEY

1-800-33-Honda **Based on R. L. Polk & Co. U.S. retail registrations, Minivan segment, 1/08 – 7/10. †A separate source device is required to use split-screen function. **Hard disk drive (HDD) 15-GB memory audio system standard on navigation-equipped models. ††The USB Audio Interface is used for direct connection to and control of some current digital audio players and other USB devices that contain MP3, WMA or AAC music files. Some USB devices with security software and digital rights-protected files may not work. Please see your Honda dealer for details. ‡19 city/28 hwy 2011 EPA mileage estimates for Odyssey Touring models with 6AT. Use for comparison purposes only. Actual mileage will vary. Touring Elite model shown. ©2010 American Honda Motor Co., Inc.*